Emotional avatars: choreographing emotional facial expression animation

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I certify that this thesis is the true and accurate version of the thesis approved

by the examiners

Signed ______________________________ Date ______________________

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Declaration

I, Robin James Stuart Sloan, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I can confirm that this has been indicated in the thesis.

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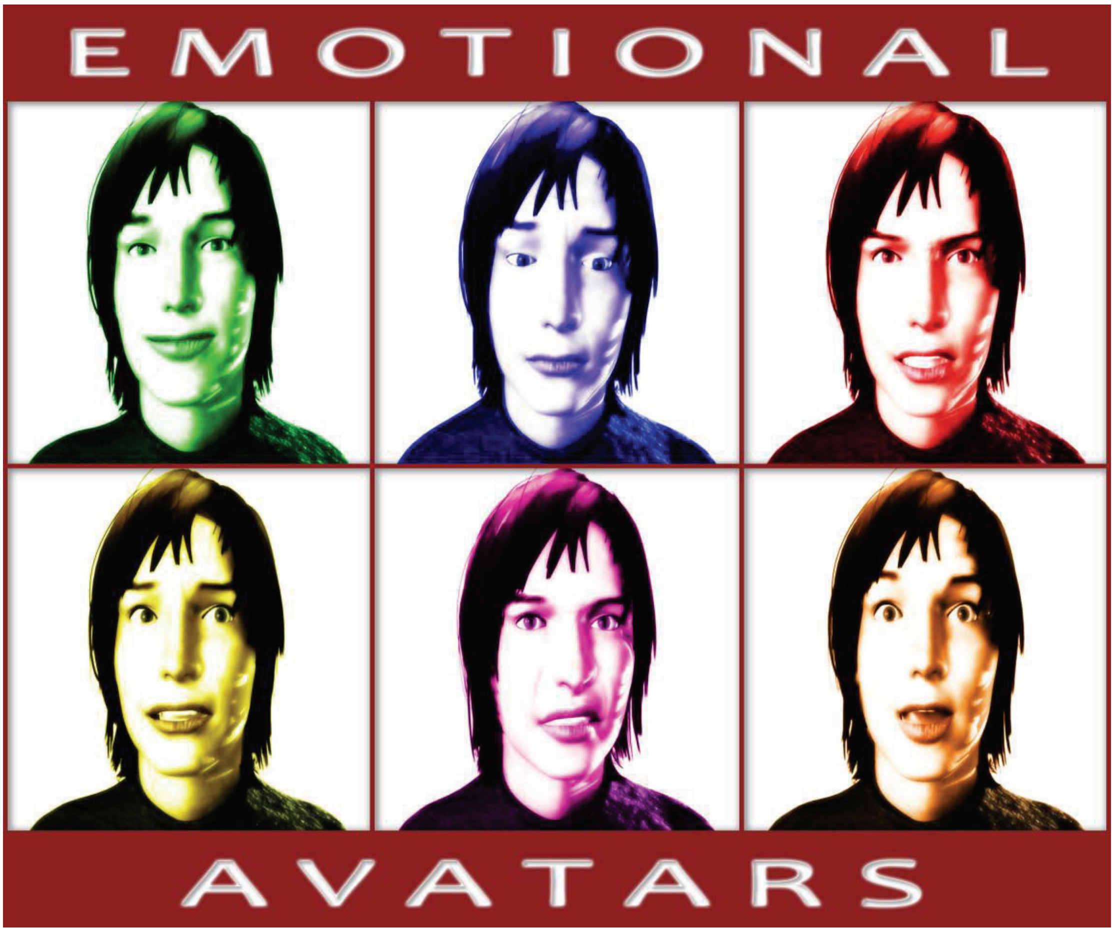

CHOREOGRAPHING EMOTIONAL FACIAL EXPRESSION ANIMATION

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Abstract

As a universal element of human nature, the experience, expression, and perception of emotions permeate our daily lives. Many emotions are thought to be basic and common to all humanity, irrespective of social or cultural background. Of these emotions, the corresponding facial expressions of a select few are known to be truly universal, in that they can be identified by most observers without the need for training. Facial expressions of emotion are subsequently used as a method of communication, whether through close face-to-face contact, or the use of emoticons online and in mobile texting. Facial expressions are fundamental to acting for stage and screen, and to animation for film and computer games. Expressions of emotion have been the subject of intense experimentation in psychology and computer science research, both in terms of their naturalistic appearance and the virtual replication of facial movements. From this work much is known about expression universality, anatomy, psychology, and synthesis. Beyond the realm of scientific research, animation practitioners have scrutinised facial expressions and developed an artistic understanding of movement and performance. However, despite the ubiquitous quality of facial expressions in life and research, our understanding of how to produce synthetic, dynamic

imitations of emotional expressions which are perceptually valid remains somewhat limited.

The research covered in this thesis sought to unite an artistic understanding of expression animation with scientific approaches to facial expression assessment. Acting as both an animation practitioner and as a scientific researcher, the author set out to investigate emotional facial expression dynamics, with the particular aim of identifying spatio-temporal configurations of animated expressions that not only satisfied artistic judgement, but which also stood up to empirical assessment. These configurations became known as emotional expression choreographies. The final work presented in this thesis covers the performative, practice-led research into emotional expression choreography, the results of empirical experimentation (where choreographed animations were assessed by observers), and the findings of qualitative studies (which painted a more detailed picture of the potential context of choreographed expressions). The holistic evaluation of expression animation from these three epistemological perspectives indicated that emotional expressions can indeed be choreographed in order to create refined performances which have empirically measurable effects on observers, and which may be contextualised by the phenomenological interpretations of both student animators and general audiences.

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Prior to returning to university, my undergraduate tutors first exposed me to digital art and design practices, methods, and methodologies, and sparked my interest in both animation and academia. I'd like to thank all academic staff within the division of Computer Arts at the University of Abertay Dundee who assisted me between 2001 and 2005. Professionally, I owe a number of people thanks for managing, supervising, and training me, as well as enlightening me to the history and practices of computer games development. Thanks to my employers, supervisors, and colleagues at both Genuine Games and I-play. As a PhD student I wouldn't have got very far without the help of other research students, so I'd like to thank my fellow PhD students throughout Abertay and those I have met across Scotland for their support, critique, and advice.

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Chapter 1
Emotional avatars:
creating believable character performances

The word ‘avatar’ has its roots in the Hindu word ‘avatara’, which is used to describe the physical form of a deity. The Hindu god Vishnu, for instance, had ten avatars, including Kurma (a turtle), Varaha (a boar) and Narasimha (a half lion, half man). In the late 20th century, ‘avatar’ as a concept was embraced by Internet and computer users to refer to the user’s graphical representation in Internet chat rooms, forums, and in computer games. This computing use of ‘avatar’ is similar to its original usage, except that the avatars of humans are alternate forms in cyberspace, while the avatars of deities are alternate forms on Earth. In the 21st century, the computing use of ‘avatar’ has become widely recognized due to the use of casual avatars on popular gaming consoles (such as the Wii and Xbox 360), and also due to the more recent commercial success of the James Cameron film *Avatar* (2009).

The genesis of the research presented in this thesis lay in the production and perception of animated computer avatars. Primarily, this start point was concerned with the artistic development of animated performances – effectively, how animation principles and creative practices could lead to the development of more believable computer avatars or virtual characters. The very nature of the research called for an interdisciplinary approach, with multiple research perspectives required in order to explore the various avenues of research. Over time, the focus of the research was concentrated on the production and perception of virtual facial expressions; in particular, how an avatar could be designed to express believable emotions using just the face channel, and how observers would interpret the nuances of the avatar's virtual performance. Consequently, the Emotional Avatars project was designed to draw upon an eclectic range of artistic and scientific methods and methodologies.

In this thesis, the Emotional Avatars project is presented and the findings are discussed. This project revolves around the work of the researcher, who – acting as a creative practitioner – developed a series of exploratory facial animations as part of the research. From these animations, further research questions were posed and addressed, resulting in the application of experimental and phenomenological methods to investigate audience perception and intersubjective reflective practice. Fundamentally, the research sought to embrace the duality of artistic practice and scientific method in order to investigate the nature and performance of emotional expression animation. The hope was that the findings would inform the production of clear, authentic, and, above all, more emotionally engaging computer-based avatars. The principle argument discussed throughout this thesis is that animated facial expressions can be temporally configured to enhance perceived authenticity.

1.1 The researcher as a practitioner

Due to the nature of the Emotional Avatars research as an arts-practice led project, it is important to note the researcher's background and previous experience as a creative practitioner. The researcher had an amateur interest in traditional and stop-motion animation from 1995, and began working with digital media in 1999. From 2000, the researcher focussed his artistic activities on 3D art and design, and on game modification and design. Between 2001 and 2005, the researcher studied for and achieved a first class honours degree in Computer Arts, developing further skills in digital media, animation, and game design. The researcher's honours year project concerned the design and development of narrative for digital games (Sloan, 2005). In 2005, animation developed by the researcher was recognized locally and internationally, with an award for Overall City Winner (Dundee) and Best New Animation (Gamer Category) at the GDCN Game Competition in Dubai. From 2005, the researcher was employed in the games sector. During this period, he took on a range of artistic and technical responsibilities (including 2D/3D art creation and animation) and has been credited as an artist on one published game to date (Genuine Games Ltd, 2006). The researcher has maintained and improved his technical proficiency in a number of digital arts packages, including; Autodesk Maya, Adobe AfterEffects, and Adobe Premiere. It is important to note that the animations created as part of the research should be considered the artistic output of the researcher within the context of his own education and experience.

1.2 Project background and rationale

As a result of previous academic study and professional practice, the rationale for this research stems from a desire to see virtual characters deliver engaging performances within interactive products. It is a personal belief that further development in virtual actor performances could influence a shift in the nature of computer games towards a more mature, narrative-driven medium, and that this in turn could contribute towards the validation of computer games as an artistic form. The premise of the project is to embrace the artistic process behind character animation as a method of research, and to demonstrate how artistic inquiry can inform the development of perceptually valid emotional facial expression animation for interactive characters. Naturally, this broad topic covers a range of research disciplines and approaches beyond traditional animation practice, in particular psychology and computer animation. In order to commence an arts-led study of facial performance for virtual characters, it is important to consider the current state of the art in computer avatars and agents, and to understand how both nature and artistic principles can inform research into virtual character animation for interactive media. Initially, however, it ought to be stated who the Emotional Avatars research is for, and how the findings of the research may benefit them.

1.2.1 The target audience

As an artist and animator, the research is primarily targeted at the researcher's peers in character animation for film and games. Character animation typically draws upon traditional artistic methods of observation and experimentation, and is driven forward by both academic research in related fields and technological progress. Animators make full use of available resources in order to inform their practice and, as such, any research into human movement may prove to be an invaluable reference. At a more focussed level, the research is targeted at computer animation researchers and developers. Advancement in real time animation of game characters could potentially enhance the artistic and aesthetic quality of games, particularly so if interactive characters could be designed to produce emotive performances. Throughout the first two chapters, it shall be demonstrated that there exists both professional and academic rationale for research in this area, and that findings could underpin future developments in game character animation. The first aspect of the project background which ought to be considered is the animation of virtual characters, the historical development of narrative in games, and the distinction between interactive and linear forms of animation.

1.2.2 Virtual character performances

Animation for computer games is often perceived as a technical exercise, more closely related to the development of techniques in computer graphics than the practice of traditional animation. This can be attributed to two of the major characteristics of computer games. Firstly, that computer games are delivered to users via a constantly changing, technology-focussed medium. While cinema is clearly concerned with advancement in technology, which can modulate the production or presentation of films, it can be argued that technology plays a less fundamental role in cinema than it does in games. Films such as *the Polar Express* (2004), *Beowulf* (2007), and *Avatar* (2009) can be considered notable exceptions; films which exist largely due to advancements in animation technology. The application of animation technology in these films is not only considered a unique selling point, but is also an area of aesthetic appreciation for audiences and critics alike. On the other hand, the visual quality of many computer games – in particular their animated effects and graphical realism – is vital. Teams of technical artists, animators, and programmers spend their time pushing the boundaries of their medium, developing in-house tools and technologies in order to create the most graphically realistic game possible. Unlike cinema, where most productions are not as dependent on effects or advanced technologies, these practices are the norm for computer games development. Ultimately, the end product is evaluated by critics who often pay close attention to graphics in their reviews in addition to matters such as game play. Promotional materials for games cite critical praise of visual quality and highlight the technical achievements of the team in producing jaw-dropping computer animation. While Pixar are commended for the quality of character animation and story in *Toy Story 3* (2010), itself a graphical tour-de-force, games such as the *Call of Duty* series are commended for their visual realism. The second characteristic of computer games that underpins game animation as a technical exercise is the move from *performance* to *agency*. In cinema, the tightly controlled narrative and passive nature of the audience caters for a focus on story and character, which in turn opens the doors for creative character animators to produce memorable performances. In contrast, the importance of agency to the computer game medium cannot be understated. Computer games *are* computer games because the user can act on and change the game world in some way, including the characters within that world. The consequence of this is that game animation typically concerns the development of interactive characters which are rendered on the fly – a technical exercise which again highlights graphical realism – while performance is a secondary consideration. Attention is given to how a character realistically moves through a crowd under the player's control, as in *Assassin's Creed* (Ubisoft Montreal, 2008), or shifts between athletic poses, as in *FIFA Soccer 11* (EA Canada, 2010). The historical development of character animation in computer games shall now be considered, with a view to contextualising the balance between performance and agency.

In recent years, the performance of computer games characters has increasingly moved to the forefront of games animation and development. For example, LucasArts have employed cutting edge techniques (originally developed for film) in order to imbue their game characters with believable performances. Their techniques not only capture voice acting, but also the physical appearance and movement of actors, resulting in accurate 3D meshes for face shapes that can be used to "achieve unprecedented subtlety of expression and nuance of performance" (Blackman and Rector, 2008, p

154). In particular, facial animation for game characters has received a great deal of attention. Facial performance-capture technology provided by Image Metrics (2008) has been used to enhance character performances in games such as *Grand Theft Auto IV* (Rockstar North, 2008), *Operation Flashpoint: Dragon Rising* (Codemasters, 2009), *Assassin's Creed II* (Ubisoft Montreal, 2009) and *Napoleon: Total War* (The Creative Assembly, 2010). In most instances, however, these refined performances are used to create believable characters in animated cut-scenes, rather than in the interactive sections of games. In other words, the game characters are driven by nuanced performance-captured facial animation when the user has no or limited control over the characters or plot – where user agency is halted. Cut-scene animation in games is more akin to cinematic animation in this respect, as the player's role is reduced to that of observer rather than actor. Indeed, cinematic conventions (such as the creative use of lighting and camera angles) are often employed in game cut-scenes.

This non-interactive facet of game character animation, while aesthetically impressive, is arguably stifling to the development of computer games as a unique artistic medium. As discussed, computer games differ from films in many ways, but the most crucial difference is certainly the introduction of agency. In computer games, users can make decisions that have very real consequences on the game world and its characters, and any move to limit or remove this agency can seriously undermine the integrity of the medium. Film audiences are more passive observers, which is why cinema has evolved to make use of non-interactive audio-visual conventions. These conventions are strictly controlled by the vision of a director, author, or creator, and are dependent on the inability of end users to manipulate characters, cameras, or scenes within the film. That computer games make use of these audio-visual cinematic conventions is perhaps understandable, as the conventions of cinema bolster a visual language that most contemporary audiences are familiar with. Application of these conventions in game cut-scenes can therefore make a game's narrative easier to interpret by film-savvy audiences. As a result, the tightly authored, more nuanced performances by virtual characters are typically presented in game cut-scenes, rather than in open-ended sections of play. In games which make use of cut-scenes for narrative exposition, players tend to be most active during sections of game-play (that are high on player agency but low on virtual character performance), and are passive during the story-driven cut-scenes woven between play (which are low on player agency, but high on virtual character performance). This model of story-driven computer game design – with distinct sections of game-play and cinematic narrative – is a typical approach to narrative delivery in mass-market titles (see Ip, 2010), including the aforementioned games *Grand Theft Auto IV* and *Assassin's Creed II*. In essence, the performances of virtual characters in current mass-market games are pre-determined and tightly controlled, presented to the player in sections of the game where he or she has little or no control. And increasingly, real acted performances are used to drive these virtual performances, using capture technologies like those provided by Image Metrics.

However, this ideology of game design as a hybrid of cinema and interactive media does little to embrace the notion of computer entertainment as distinct artistic form. As Murray describes in her seminal book on computer-based narratives, the future of computer-based narrative ought to be likened to the Holodeck of the science fiction series *Star Trek*, which immerses users in:

> "…an illusory world that can be stopped, started, or turned off at will but that looks and behaves like the actual world and includes parlor fires, drinkable tea, and characters… who can be touched, conversed with, and even kissed."
> (Murray, 1997, p 15)

In this vision, the virtual characters do not act out pre-determined animations that are defined or driven by previously acted performances. The technology for capturing the nuanced performances of actors is irrelevant here, as the virtual characters *are* the actors; they are programmed with character traits, behaviours, and desires. They interact with the user, and act out believable, real-time performances. The Holodeck is both high on player agency and high on virtual character performance. There have been many attempts to develop interactive digital games that contain characters whose performances (verbally and visually) are partially determined by the actions of the user. ELIZA (Weizenbaum, 1966) is perhaps the earliest example of an interactive virtual character – in this case, a kind of virtual therapist that was programmed to interpret and respond to typed statements from the user. Following on from ELIZA, interactive fiction (text-based adventure games) emerged in the 1970's, with Will Crowther's *Colossal Cave Adventure* often cited as the start point of the genre. An in-depth analysis of the development of Colossal Cave Adventure (Jerz, 2007) – including examples of source code and an exploration of the real world environment on which the game was based – documents the cultural impact of interactive fiction in general and Colossal Cave Adventure in particular. With interactive fiction, the fusion of interactivity and story created a unique artistic form, empowering a new breed of computer artists to draw upon their programming and writing skills to produce expressive and immersive interactive media.

Graphical adventure games evolved from early text-based games, and ultimately usurped their predecessor by appealing to a wider (more commercial) market. Of this new breed of interactive fiction, the graphical adventure games developed by LucasArts using the SCUMM engine were among the most critically and commercially successful. One such example – *the Secret of Monkey Island* (Lucasfilm Computer Division Games Group, 1990) – features a cast of non-playable characters (NPCs) which respond to user actions such as 'talk to', 'give' and 'push'. Some characters can also be conversed with, allowing the user to select conversational statements or questions (see Figure 1.1). Typically, graphical adventure games contain minimal action-orientated sections of game play, to the point where even sword fights in *the Secret of Monkey Island* are based on verbal exchanges rather than physical attacks. As a result, the emphasis of the graphical adventure game is on story and the development of both the playable and non-playable characters. With the exponential advance in computational and graphical power since the genre's popularity peak in the early 1990's, the graphical adventure game would seem to be the appropriate design model for a true Holodeck experience, uniting agency and performance.

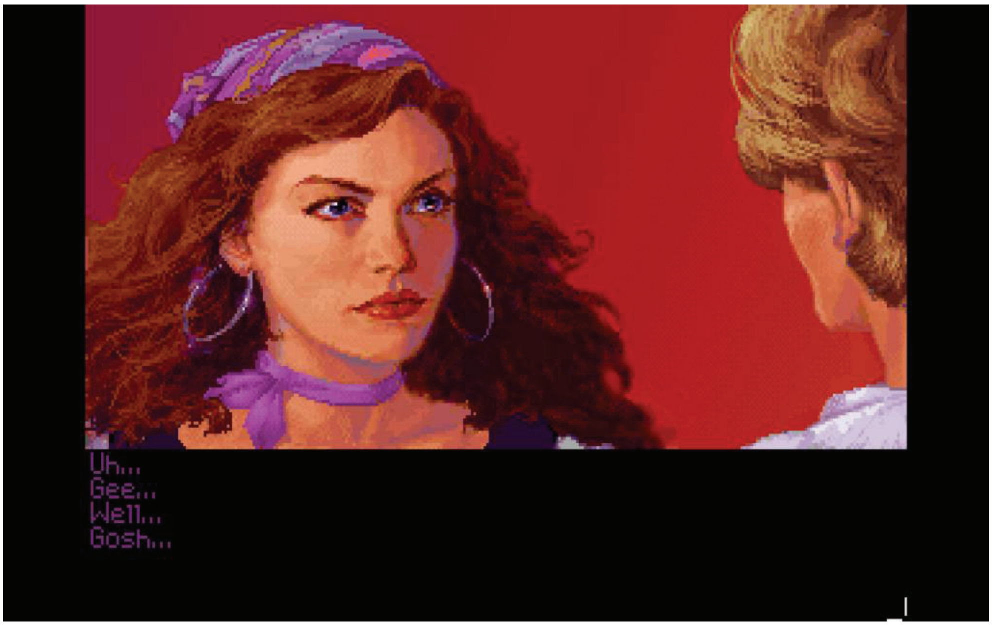


Figure 1.1. : Screenshot of a conversation with a non-playable character in the Secret of Monkey Island (Valve Corporation, 2009a).

In more recent years, traditional adventure games have waned in popularity, even if the re-release of an updated version of *the Secret of Monkey Island* in 2009 somewhat reinvigorated the genre. That is not to say that the demand for interactive story content in games has also waned, however. While graphical adventure games have declined, action game developers have sought to place more emphasis on character, story, and plot in their products. This has resulted in the explosion of mass-market games which straddle the boundaries between gaming and cinema – those which make extensive use of cinematic cut-scenes, as discussed earlier. In the late 1990s and early 2000s, action game developers – who previously showed little concern for narrative immersion in their products – began to hire dedicated game writers, which ultimately impacted on the game design process. For example, Marc Laidlaw (writer at game developer Valve) indicated that, without his involvement as a writer in the development of the first-person shooter *Half-Life* (Valve Software, 1998), the game might well have ended up as yet another stereotypical action game (Graft, 2009). By the time the sequel *Half-Life 2* (Valve Software, 2004) came along, the writers had become a more integral part of the development team, taking advantage of advancements in real-time animation technology to develop emotionally engaging characters. One such NPC – Alyx (see Figure 1.2) – was responsible for bringing the player-character to life through her carefully scripted and animated performance, and through her emotional relationship with the player:

> "She gives back to you emotion, which is the only way we can tell the internal story of Gordon Freeman [the playable character] – by the way the other characters treat him. So having characters like you and glad to see you, you think, "oh, I'm an important person in this world." Alyx was a great way of affirming that, and the things that are perilous to Alyx are going to be things you care about."
> (Marc Laidlaw in Graft, 2009, p 4)

By imbuing a pivotal character with an emotional connection to the player, *Half-life 2* represented a key moment in games narrative, ticking many of the boxes regarding NPC development and emotion as suggested by Freeman (2004). However, while games like *Half-Life* have added greater depth of narrative to computer games, most of these games still offer relatively little scope for true interaction with NPCs on an emotional level, instead favouring cinematic or semi-interactive cut-scenes (as in *Half-Life 2* and the vast majority of its contemporaries). When non-interactive cut-scenes are used to deliver rigid or limited storylines, the process of animating

Figure 1.2: The nuanced virtual performance of the NPC Alyx provides the player with an emotional connection to the game world in Half-Life 2 (Valve Corporation, 2009b).

emotionally engaging game characters is relatively straightforward, and again subject to technical intervention. For instance, there is no reason why facial performance capture (like the service provided by Image Metrics) cannot be used to produce the nuanced facial animation of characters like Alyx. Indeed, even when Alyx's animated performance is presented outside of cut-scenes (in interactive sections of game-play), the fact that the player has little scope for meaningful emotional interaction with the character means that, theoretically, performance-captured animation could be used to drive her at *all* times. The computer does not need to 'know' how to make Alyx perform; it needs only to 'know' which animations to play at certain points in the game-story. In this sense, the procedure for animating emotionally charged game character performances need not be that different from the systematic process of animating physical character movements such as walks, runs and jumps, where libraries of pre-defined movements are generated by animators and then accessed in real time. Indeed, research into the animation of emotionally engaging NPCs has in the past drawn upon this standard library-based method of animation production and playback (Tomlinson, 2005). Yet today, it is clear that there is a growing desire to rethink how animated character performances are dealt with in computer games (Moleman, 2009).

Some contemporary games have provided the user with more opportunities to manipulate their virtual relationships with NPCs, resulting in dynamic storylines and character performances. In *the Elder Scrolls IV: Oblivion* (Bethesda Softworks, 2006), while the overarching narrative is fairly linear, the player is able to interact with characters in the game in much the same way as in *the Secret of Monkey Island* (see Figure 1.3). One feature actually allows the player to manipulate the emotional state of the NPCs through simple actions. This in turn results in slight changes in animated facial expression. Games like *Fable II* (Lionhead Studios, 2008) encourage a greater range of NPC relationship interactions, with support for virtual relationship development based on player actions. This includes actions that directly affect the relationship with the NPC, such as blowing the NPC a kiss, as well as indirect NPC relationship manipulation, such as the impact of the player’s moral judgements (see Figure 1.4). The development of relationships between the player and NPCs in *Fable II* could result in the player acquiring virtual friends, enemies, spouses, and even children. Moreover, the emotional and moral development of the player character influences how the overall story is told.

While this idea of intermingled game-play and story in commercial computer games is in its infancy – and despite the fact that this very concept presents a fundamental conflict between narrative and play in games like

Figure 1.3: Character interaction in the Elder Scrolls IV: Oblivion (Bethesda Softworks LLC, 2006).

Figure 1.4: Development of character relationships through real time interaction and player decision making in Fable II (Microsoft Corporation, 2010a).

Fable II (Short, 2009) – the success of games that revolve around virtual relationships suggests that we will see ever-more complex and intriguing examples of virtual character performance and true emotional interaction with NPCs in the near future. A clear example of how imminent this future may be was presented to the world in 2009, when Microsoft unveiled details of Project Natal (later renamed Kinect). Kinect is a controller-free interface for Xbox 360 that makes use of video cameras and sound recognition (Microsoft Corporation, 2010b). Part of the technical demonstration at the Electronic Entertainment Expo (E3 2009) centred on a presentation by Peter Molyneux, creative director of Microsoft Game Studios, Europe. During this presentation, a player was shown interacting with an NPC – Milo – using only the Kinect interface (see Figure 1.5). Although this demonstration was pre-recorded and not representative of a fully operational game, the demonstration strongly indicated the direction game and hardware developers are headed, and the desire developers and players have for empathetic interactive virtual characters that can display genuine emotions and react (in real-time) to the actions of players. It is clear that significant research is still needed (theoretically, technically, and in terms of creative interactive performance) before anything like the idea of Milo can come to fruition. Nevertheless, the

Figure 1.5: The 'Milo' interactive virtual character game concept by Lionhead Studios, utilising the Microsoft Xbox Kinect technology (IGN Entertainment Inc, 2010).

fact that Microsoft placed the Milo demonstration at the forefront of its E3 2009 presentation indicates that mass market game developers recognize the demand for emotionally engaging, story-orientated commercial games.

While current commercial games contain NPCs which deliver interactive performances, the performances themselves so far have been fairly generic, and the capacity for interaction is, in most cases, limited. This could well be down to what may be considered the primary function of games, which is not to serve as interactive stories, but as digital play-based challenges. Crawford (2004) picks up on this point, suggesting that the “utter failure of games to incorporate storytelling in any but the most mechanical and forced manner” is due to their focus on things, rather than people (p 15). The Milo concept challenges the status quo by refocusing on people, both actual and virtual. But for now, the Milo character remains only a concept.

Experimental games, however, have shown how more elaborate stories and interactive character performances can be developed using games technologies. Façade is an “artificial intelligence-based art/research experiment in electronic narrative” (Procedural Arts, 2008a), essentially a short interactive drama in which the user can interact with two NPCs (Figure 1.6). The user interface in Façade is more similar to text-based interactive fiction than contemporary graphical games, in that interaction with the characters is handled through textual input and natural language processing (Mateas and Stern, 2005). Although focussed on artificial intelligence (AI) rather than interactive performance animation, the virtual characters in

Figure 1.6: Screenshot from interactive drama Façade (Procedural Arts, 2008b).

Façade respond visually, displaying non-verbal cues that betray their virtual thoughts, feelings and emotions. Furthermore, a subsequent augmented reality experiment featuring Façade (Dow et al., 2006) exhibited obvious similarities with the fictional Holodeck of *Star Trek*, and would appear to be the biggest move towards the Holodeck-as-reality thus far.

Philosophically, the idea of interactive narrative (the combination of performance and agency) using computer technology has been well explored, although there is still much debate between the competing ideologies of narratology and ludology. The very notion of a narrative as anything other than an explicitly authored artwork has itself been questioned (Juul, 2001), while theoretical models for digital literature have been proposed and debated (Aarseth, 1997; Ryan 2001). Potential narrative structures for commercial games have been highlighted (Meadows, 2002), while the evolutionary link between the emergence of games and narrative has even been examined (Murray, 2006). In terms of technological development and assessment of interactive fiction, projects similar to Façade continue to explore the use of interfaces and artificial intelligence to enhance interactive dramatic performances (e.g. Cavazza et al., 2009; Corradini et al., 2009; Mehta and Corradini, 2009). Lessons from the performing arts have been taken into account when creating interactive narratives (Seif El-Nasr, 2007). And yet – despite the fact that interactive stories and emotionally charged games are of clear interest to researchers, developers, and audiences alike – an area which remains relatively underexplored is the dynamic visual performance of NPCs. While research into AI can help to inform how characters behave, react, and converse, character movements determined by the AI are currently based on either libraries of animation developed by animators, or a mixture of predefined and procedural animation; for instance by using animation software such as Endorphin (NaturalMotion, 2006) to create dynamic physical animation. At present, very little is known about emotional dynamic character performances, which means that nuanced virtual character performances are likely to remain constrained either to libraries of predefined animation or to non-dynamic performance capture. Psychological research into natural facial appearance and perception (Ekman and Friesen, 1975) can and has informed the development of procedurally animated virtual characters (e.g. Arya et al., 2009). But the acted and animated performances of characters in film and linear animation are ultimately the outcomes of artistic endeavour, not strict natural realism.

In terms of animated facial performance for virtual characters, there exists a significant gap in our knowledge of what makes for an authentic dynamic emotional expression, and how procedural variation in the sequence and timing of movements can manipulate audience interpretation and the perceived context. Research has shown that users can feel empathy for virtual characters when they find them believable, and if they also believe that their actions can affect the behaviour of virtual characters (Hall et al., 2005). But again, this idea of believability is not necessarily synonymous with natural realism – it is also concerned with the artistic notion of suspension of disbelief. The movement of virtual characters is therefore highly important from both naturalistic and artistic perspectives; believable virtual character performance must be informed by underlying behaviours and emotional impulses, but performances must also be crafted artistically in order to communicate the nature and intensity of emotion in a clear and authentic way. In essence, virtual characters must be able to act:

> "It is my contention that… we will not find a way to create intermediate agency that will allow the viewer to find their way into caring about characters, until we provide a way that characters can act well enough to embody an interactive narrative."
> (Perlin, 2004, p 17)

In this sense, research into the animated performances of virtual characters is a crucial piece of the puzzle when it comes to understanding how to develop empathetic, interactive performances. All character animation must take influence from the artistic principles of traditional animation production, but it must also have some basis in natural human movement and emotional displays. In order to begin an investigation into how emotional character performances can be produced on the face, it is important to consider the roles of naturalistic nonverbal communication and the core artistic principles of animation.

1.2.3 The nature and performance of emotion

While it is clear that a degree of artistic interpretation is crucial when it comes to animating believable characters, it is also clear that nonverbal forms of human behaviour and communication occur in nature, and that understanding how these nonverbal cues appear is essential to building perceptually valid virtual character performances. Argyle (1988) breaks down the various forms of nonverbal behaviour into a range of signal types; facial expression, gaze and pupil dilation, gestures and other bodily movements, posture, bodily contact, spatial behaviour, clothes and other aspects of appearance, nonverbal vocalisations, and smell. There are also many variables which impact upon the appearance and interpretation of these nonverbal signals, such as the direction of gaze, the speed or intensity of movement, or the effect of cultural differences (the last of these being of particular importance to the project, as will be discussed shortly). Furthermore, nonverbal behaviour can serve different functions which may be dependent on the situational context. Despite this complexity, the nature of nonverbal behaviour has been well explored through development of theory and related empirical research. As a result, much is known about the purpose and appearance of certain nonverbal signals. Consideration of this research is crucial when it comes to contextualising the background of the Emotional Avatars project.

In terms of the purpose of nonverbal behaviour, one of the most obvious functions is the expression of emotion, which is primarily conveyed through the face, body, or voice (Argyle, 1988). This would clearly be the function of nonverbal behaviour most relevant to the current research. However, underlying models of nonverbal behaviour would suggest that emotional expression is just one facet, and may not even in itself be considered a primary function. Patterson (1983) suggests five general functions for nonverbal behaviour; providing information, regulating information, expressing intimacy, exercising social control, and facilitating service and task goals. Within Patterson's framework for functional analysis, emotional expression would therefore be considered an aspect of the informational function, and it is this particular aspect – the communication of information through nonverbal (and, specifically, facial) cues – that must underpin research into emotional virtual character performance.

The universality of nonverbal behaviour is a topic that has been scrutinized in anthropology and empirical research. On the one hand, certain nonverbal behaviours can be said to be evolutionary in nature, or 'universal' and culturally independent. These types of behaviours may be apparent across species, not just across cultures – for instance, the homology of nonverbal facial displays in primates has been researched, indicating that humans share nonverbal behaviours with their evolutionary ancestors (Preuschoft and Van Hooff, 1995). On the other hand, the emergence of culture can be said to influence the display of certain nonverbal behaviours (Izard, 1969; Leach, 1972). In order to animate virtual characters which are not only perceptually believable, but also culturally independent, it is therefore important to consider the wealth of research that has looked to determine to what degree certain nonverbal behaviours are universal. For instance, in terms of communication through facial displays, it has been shown that the quick raising then dropping of the brow can be considered a universal form of greeting (Eibl-Eibesfeldt, 1972). Consideration of a universal cue such as the eyebrow flash is vital to a study of emotional facial animation that can be generally regarded as believable, as this particular cue clearly communicates a cross cultural idea. Mishandling of this specific movement may result in audience confusion if, for example, it appears within an animated emotional expression. Another universal trait identified by Eibl-Eibesfeldt (1972) is the easily identifiable nonverbal communication of embarrassment, in which the face is hidden by the hands. Through study of acted performance, or even simply through artistic reflection and instinct, an animator is likely to come to the conclusion that this is a suitable movement to use in conjunction with a feeling of embarrassment. However, it could well be that nonverbal traits that are instinctively seen as appropriate by animators (who are ultimately influenced by their own cultural contexts) are in fact culturally dependent. This is why knowledge of the true universality of nonverbal displays, underpinned by scientific study, is crucial to the Emotional Avatars research. As such, a review of the literature in the next chapter will seek to identify the accepted universality of emotional facial expressions, their appearance, effects on perception, and potential dynamics.

When conducting research into the synthesis of believable animation, a primary concern is the source of informative data. Generally, it is appropriate to look to nature in order to record and analyse the nuances of naturalistic, spontaneous expressions. Additionally, posed or acted expressions are typically used to inform the animation of synthetic expressions for emotional computer agents. Both of these approaches to expression data acquisition were ultimately adopted for the Emotional Avatars research[1]. However, there are further approaches that can be used to record and present dynamic expressions. Clips may be cut from TV shows, news broadcast and films, for instance. Motion or performance capture is of particular relevance to the field of computer animation research, and this shall be covered in more detail in the next chapter. Perhaps the most overlooked means of producing data for research into facial expressions, though, is the artistic process of key frame animation. In her presentation at the Affective Computing and Social Signal Processing summer school in Edinburgh, 2010, Catherine Pelachaud listed traditional or key-frame animation as one of the many methods of acquiring facial expression data, underlining the validity of this creative process as a means to conduct scientific study (Pelachaud, 2010). It is perhaps somewhat surprising, especially to those who are animation practitioners, that the traditional methods of animation production are not employed more frequently in formal computer animation research.

Above all, the principles of animation developed by the Disney Studio underpin the production of perceptually valid character animation. The twelve principles are used to train animators in the observation and imitation of lifelike movement, and the creation of unambiguous and appealing animations. The clarity of an animated character's expression, for instance, would be informed by the principle of Staging:

[1] The methods of collecting naturalistic and acted expression data are covered in some detail in Chapter 4.

> "Staging is the presentation of an idea so it is completely and unmistakably clear; this principle translates directly from 2-D hand drawn animation. An action is staged so that it is understood; a personality is staged so that it is recognizable; an expression so that it can be seen; a mood so that it will affect the audience.
> (Lasseter, 1987)

Lasseter argues that the principles of animation are fundamental to audience perception, and that principles such as “staging, anticipation and timing are all integral to directing the eye” (Lasseter, 1987). Clark expands on the idea that audience interpretation of animation is the key to success, pointing out that "animation is, at its core, a communicative language” (Clark, 2002, p 165). On giving advice to animation practitioners, Clark professes that

> “…your primary goal is to clearly communicate your given message in such a way that there is no ambiguity or doubt about your character's thoughts and actions. When you're trying to convey a message, you must provide clarity. If your message lacks clarity, it becomes muddled, confused, and oftentimes unintelligible.”
> (Clark, 2002, p 165)

Good animation is therefore all about perception and interpretation, especially so in the realm of commercial animation where the core purpose of the animation is to communicate an idea, product, or narrative. In this sense, it might seem that the best way to understand how to animate characters would be to look exclusively at how real humans and animals move, specifically movements of the body and face that amount to naturalistic nonverbal communication. After all, the vast majority of audiences are well equipped (through evolution, culture, and social conditioning) to understand these non-verbal cues. However, humans in nature are not always clear and unmistakable, and the principles of animation certainly do not apply to natural human movement. Animation is an art form, and as such it makes use of artistic practices and draws upon artistic experimentation, reflection, and creativity. While studies of nature and scientific inquiry are relevant, creativity must also take place in order to produce believable character performances:

> "…movie-making at Pixar is a technical effort subject to creative control. The essence of Toy Story is in its lifelike characters; the characters are lifelike primarily because of creative control (the realm of Art), not technical prowess (the realm of Science)."
> (Porter, 1997, p 11)

Evidently, the creative practice of character animation can produce characters that generate strong feelings of empathy in audiences; emotional facial expressions that observers connect with, understand, and are affected by. Therefore, it could be argued that animation theory and practice is a pertinent area of research in itself, particularly so for an investigation into the believability of dynamic emotional facial expression. Subsequently, the prominent literature in animation practice shall be covered in Chapter 2, focussing in particular on the principles of animation, the pitfalls of real-world replication in animation, and current practices in facial animation.

1.3 Professional rationale

As stated at the start of this chapter, the initial premise of the research was that the artistic production of facial expressions in animation could be embraced as a means of generating new knowledge of expression animation, and that this new knowledge could be applicable to the development of avatar performances in interactive media. The background of virtual character performances suggested that this premise filled a niche, and that practice-based research would indeed be of value. In particular, if knowledge derived from creative practice could be shown to predict and explain measurable audience interpretations of animation, then research findings would be of immediate interest to professional practitioners working on character animation for games. With regard to the current state of the art in terms of facial animation technology, a significant gap in the procedural animation of believable expressions is clearly evident, as identified by Deng and Noh:

> "Because of the complexity of human facial anatomy and our inherent sensitivity to facial appearance, there is no real time system that generates subtle facial expressions and emotions realistically on an avatar."
> (Deng and Noh, 2007, p1)

The lack of a perceptually valid real-time animation system for facial expressions is not the result of an inactive research community in either emotional psychology or computing (these areas of research will be discussed in the next chapter). Instead, our current understanding of facial expression synthesis is restrained by the sheer complexity of the subject matter, just as Deng and Noh state. The rationale for the Emotional Avatars research is rooted in the idea that believable real-time facial animation should be possible to create, and once achieved could be applied across a range of projects (including computer games entertainment). The introduction of creative animation practice as a potential vehicle for research in this area represents an additional rationale, both in terms of harnessing new artistic knowledge generated through animation production, as well as the novelty of developing an appropriate animation-led research methodology. To explore the state of the art in real-time animation technology, the role of animation production in research, and the value of audience assessment to practice, requests for informal interviews with senior technical, artistic, and animation staff at UK-based professional games companies were made in early 2008. In July 2008, two such interviews were conducted at game studios; the first with Jolyon Webb (creative manager of TrueSim, the serious gaming division of Blitz Games), the second with Robert Strand (senior animator at Codemasters). The full audio files for these interviews and an overview of the key comments are provided as Appendix I. As a result of these interviews and subsequent informal meetings with professionals and academic colleagues, the idea that the display of dynamic expressions could be better understood became fully established as the primary purpose of the project. In particular, it seemed of interest to investigate the notion of an ideal timing within the face (during and between expressions of emotion), and it was established that research in this area could reveal how best to animate virtual facial performances. The notion that a 'recipe book' for authentic facial animation could be produced as a result of the research emerged as an ideal project outcome. Review of the associated literature on facial animation production and the development of interactive characters (see section 2.3) demonstrated the expanded academic rationale for such a study. From here, the concept of emotional expression choreography was proposed – an idea that led to the refinement of the overall project aim and key research questions.

1.4 Project aim

With the initial idea that creative animation practice could reveal a better understanding of dynamic facial expression configurations, the following project aim was proposed.

> ‘To conduct practice-based studies of animation in order to explore the concept of emotional expression choreography, and develop an artistic understanding of dynamic expression animation that can be assessed and contextualised through studies of human perception and interpretation.’

This aim requires further explanation, firstly by providing a more detailed dissemination of what exactly is meant by emotional expression choreography.

1.4.1 Choreographing believable emotional facial expressions

An early concept that emerged from practical experimentation and discourse with creative arts academics and professionals was the idea that facial expressions could be choreographed. This concept also stemmed from the researcher’s study of Laban Movement Analysis (LMA) (Newlove, 1993). LMA is a method for describing and visualising the movement of the human body, with particular emphasis on the performance of movement. With four primary categories – body, effort, shape, and space – LMA can be seen as a rigorous and methodical means of designing and critiquing the performance of movement. It was after consideration of LMA and discussion with animation academics and professionals that the idea of emotional expression choreography (EEC) was proposed. The underlying concept behind EEC is that animated facial expressions must be perceived as valid by audiences. A perceptually valid expression should be deemed as one which appears lifelike, triggers an empathetic response in the audience, and accurately communicates the intended emotional state of the character. It is possible, for instance, for a deliberately insincere expression (such as a faked smile) to appear perceptually valid – it is valid because it looks like a believable animation of a fake smile (providing that this is what the animator intended to show).

The basic idea of EEC was seen as a useful avenue for research from a purely artistic perspective. For instance, if studies of EEC could reveal the most effective ways to choreograph nuanced facial movements for particular emotional states, then this in itself would be useful to traditional animators working with linear media. However (and perhaps more significantly) if a study of EEC could help to establish a viable code for facial movements, then theoretically it would be possible to expand this knowledge to real-time character animation software. In other words, the performances of computer avatars (see section 1.2.2) could be enhanced through the procedural animation of nuanced emotional expression movements which would be determined by real-time interaction with the user and the environment. For instance, if a study of EEC could show that a character who feels angry as a result of a particular contextual stimulus (e.g. being bullied) is most believable when the face moves according to a specific configuration, then that information could be used to drive character animation in interactive media.

1.4.2 Investigating choreography through artistic practice

This concept and the resulting hypothesis called for a range of research questions which would, ultimately, rely on the application of very different research methods. Firstly, studio production of facial animation was acknowledged as fundamental to the research. Animation practice would cater for an exploratory study of the intricate details of expression movement. Furthermore, artistic principles and acted performance could be used to reveal subjective yet informed insights into the role of emotional expression choreography, and potentially predict which facial configurations would have the most effective results on audiences. Animation practice, therefore, was established as the leading method of research for the project.

1.4.3 The effect of choreographed expressions

Animation practice alone, however, could not be used to produce objective, empirical results. The findings of arts practice can be enlightening, unexpected, and laced with subjective meaning, but the methods of art-based research are not adequately positioned to detect whether variation in facial dynamics have any discernable effects on audiences. Instead, the positivist approach and application of scientific methods can be embraced in order to take careful measurements of observer perception while viewing animated stimuli. Ideas such as the clarity, intensity, and authenticity of choreographed expressions can be assessed using the experimental method, and statistical analyses used to test whether artistic manipulation of facial movement significantly impacts on perception. As such, quantitative methods were underlined as the second aspect of the Emotional Avatars research.

1.4.4 The context of choreographed expressions

Despite covering both the artistic expression and scientific assessment of choreographed expressions using these two methodologies, a third angle on facial expression research was identified. While the arts-based research could reveal the deeper meaning behind facial performances, the quantitative research could only be used to assess audience perception using clearly defined measurements. However, not all aspects of emotional expression choreography can necessarily be covered by unambiguous measures; for instance, subtle variation in timing, intensity, or duration could infer a deeper, interpretive understanding of expressions. As such, a qualitative methodology was selected in order to explore how animators and audiences interpreted EEC. All three research paradigms are covered in detail in Chapter 3.

1.5 Thesis outline

The written thesis consists of seven chapters detailing the background, related research, methodology, and the results of research. In Chapter 2, the related literature is broken down into three categories; a review of research into the natural occurrence and appearance of facial expressions, research through animation and creative practice, and methods for reproducing or replicating expressions in computer animation. Chapter 3 concerns the conceptual framework and research methodology of the Emotional Avatars project. This chapter opens with an overview of the project goals, followed by sections on the three selected research perspectives for facial animation research, before a discussion of the selected mixed-methods design. The results of the various research methods are discussed in chapters 4 through 6. Chapter 4 focuses on the results of performative (arts-led) research, including the collection and study of reference material, development of facial animation setup, preliminary explorations through animation, and studies of EEC. Chapter 5 concerns the use of experimental methods for measuring audience responses to dynamic expressions. This consists of the development of the experimental method and two detailed experiments that were designed to measure observer perception of creatively animated facial expressions. The results of qualitative research – using phenomenological methods – are presented in Chapter 6. This chapter opens with a phenomenological analysis of the practitioner-researcher's experience, followed by the results of studies into intersubjective animation production and perception. Finally, a discussion of the overall research findings, project conclusions, and future directions are presented in Chapter 7. This includes reference to the 'recipe book' produced as an outcome of the research. The Emotional Avatars research was conducted using both practice-based and scientific research methods, and as such a proportion of the research outcomes consisted of drawings, animation, and exposition. Furthermore, descriptive writing of both the personal experiences of the researcher and the experiences of participants formed part of the investigation. Elements of these outcomes are included on the accompanying DVD, with a full list of DVD contents provided in the Appendices.

Chapter 2
Emotional facial expressions:
appearance, perception, and production

> "The wealth of details that make Bugs Bunny the compelling personality that he is were created by talented artists who carefully crafted every detail of his motion, with all of the principles of animation, human common sense, knowledge of (cartoon) physics, emotional psychology, social skills and acting ability at their disposal. This human artistic knowledge guided their decisions at every moment of their linear film to bring the character to life. For fully autonomous, interactive characters to approach this level of richness, we must enable skilled artists to craft each of these details procedurally, so that the interactive character can have the knowledge it needs to make the right decisions at all of the moments of its interactive "life." This information must be encoded procedurally in the character, because the artist will not be there to help make the decisions when the character is executing, and because the character has to make the right interactive choices that the artist would make if they were there."
> (Loyall et al., 2004, p 59)

This summary of the process of building interactive character performances touches on several key points. Firstly, that animated characters with "compelling personality" are the products of insightful, artistic practice, and that the knowledge animators need to animate believable characters stems from practice-based experimentation and reflection (i.e. the principles of animation and cartoon physics). Secondly, that an understanding of both emotion and human psychology is crucial to the creation of empathetic characters. And finally, that animators cannot be called upon to create refined character performances in real-time and in response to all possible user interactions in computer games and interactive media. As the demand for believable, interactive virtual characters continues to grow, so too does the need for high performance, emotionally charged procedural animation.

In this chapter, a review of the related literature will be presented. This will commence with an examination of research into the natural occurrence and conveyance of emotion. As stated by Loyall et al. (2004), an understanding of emotional psychology is paramount when it comes to crafting believable, empathetic character animation. For the purposes of the Emotional Avatars research, an overview of emotional processes and the typical physical manifestation of emotional states is needed, not only for the production of animation, but also for informed evaluation of animation outcomes. The literature reviewed in the first section of this chapter therefore relates to the psychology and processes of affective states, prominent theories of emotional experience, the universality of facial expressions of emotion, and the key factors which may manipulate the experience and expression of emotion. In the next section, the focus of the review shifts to the creative processes of traditional and computer animation. Returning to the opening quote by Loyall et al. (2004), the purpose here is to identify how creative animation practitioners have tackled the problem of creating believable characters. Building on the discussion in Chapter 1, the principles of animation shall be covered in some detail, with examples of how creative principles can generate emotive characters which are arguably more lifelike than their performance-captured counterparts. This will be followed by a focussed review of the creative animation of facial expressions, in particular highlighting the current knowledge and expert advice on how believable emotional expressions can be animated. In the final section of the chapter, the review shall shift to research into expression dynamics, methods of synthesizing dynamic expressions of emotion, and the state of the art in embodied agents. It is within this review that a significant gap in our current understanding of facial expression animation shall be identified, and that the rationale for research into the concept of emotional expression choreography shall be underlined.

2.1 The nature and appearance of emotions

> "the face… is a legitimate focus of study, and if one wants to learn what information can be learned from this multisignal system, then it is important to determine all the different kinds of information – messages – these signals can provide."
> (Ekman, 2005, p 605)

The above quote by Paul Ekman succinctly identifies facial studies as both a meaningful and immensely complicated research area. It is perhaps telling that, despite detailed and intensive research into how facial expressions appear and are perceived, there are still many gaps in our understanding of facial cues. When dynamic, moving expressions are taken into consideration, the complexity of this field increases exponentially. A general study of facial expressions would warrant both a broad and detailed review of the literature on human face research. For the purposes of a study of believable dynamic expression animation, however, this section is focussed on the texts which underline what we understand about emotional processes and the related emotional facial expressions. At the outset, the nature of the underlying emotions must be examined. As Ekman highlights, the face is the site of multisignal information, yet the information that is conveyed through the face is derived from intrinsic processes. Theories of how emotions emerge and are experienced will therefore directly impact on both the animation and evaluation of emotional facial expression animation.

2.1.1 Emotions and other affective states

Firstly, let us define what is meant by an emotional state. This may seem a trivial point, but it would appear that there is potential for overlap between different forms of affective states. It is clear that a range of affective states exist (Plutchik, 1980) and as such it is imperative that a distinction is made, particularly between emotion, mood, and temperament. Davidson (1994) identifies duration as an obvious distinction between mood and emotion, a view which is shared by other researchers, including Ekman:

> "What we call moods last much longer than emotions. While there is no agreement about how long an emotion typically lasts, most of those who distinguish emotions from moods recognize that moods last longer."
> (Ekman, 1994a, p 56)

However, Davidson also purports that a more meaningful distinction between mood and emotion is in their impact on the subject's actions or thought processes. Broadly speaking, emotion can be said to "bias action, while moods bias cognition" (Davidson, 1994, p 54). In this sense, the shorter-lived emotions may be seen as more intense affective states that drive the person experiencing the emotion to take some form of action in response to the emotional stimulus (Niedenthal, Krauth-Gruber and Ric, 2006, p 3). Longer lasting moods, on the other hand, impact on our cognition and modulate our emotions. The mood that we are in may make it more or less likely that a particular emotion will be felt in response to a stimulus. For instance someone in an irritable mood may be more likely to become angry, and have a lower threshold for arousing the emotion (Ekman, 1994a). A distinction can also be made in terms of the origin of emotional and mood states, in that an emotion typically has a clear stimulus while moods do not necessarily stem from a specific eliciting event (Parkinson et al., 1996). As a longer lasting affective state, moods can generate associated thoughts and feelings – or meta-moods (Mayer and Gaschke, 1988) – while emotions may be too fleeting to produce similar cognitive responses. Still, there are areas of significant overlap between emotions and moods. For instance, unlike many other affective states, it can be possible to regulate both emotions and moods (Thayer, Newman and McClain, 1994). Overall, the relationship between mood and emotion would appear to be strong, and any study of emotional expression ought to take account of mood as a contributing factor to both the experience and the resulting facial expression.

While mood and emotion represent two types of affective state where a clear distinction may be difficult to make, there are other affective states where a distinction from emotion is more obvious. Temperament can be thought of as an individual's tendency to experience and exhibit particular emotional states (Goldsmith, 1993), and may commonly be associated with personality traits. In this sense, a person's temperament can also be considered a contributing factor to how an emotion is elicited and experienced. There is evidence that temperament can be determined (at least partially) by genes (see Davidson, 1994). For the purposes of a study of emotional expression animation, it is crucial that what constitutes an emotion is clearly understood and distinguished from other character states. While there may be overlap between what we commonly think of as either emotions or moods, emotional states are typically short lived responses to internal or external stimuli, and typically lead to the taking of action (this latter point will be discussed in more detail shortly). Other forms of affective state – particularly mood and temperament – may be useful considerations for artists when producing and evaluating emotional expression animation, as both may commonly impact on emotional states.

2.1.2 Theories and models of emotion

In order to understand human emotional experience, many theoretical models have been proposed that attempt to rationalise what is, in effect, an enormously complex development of feelings and thoughts. At an evolutionary level, emotions can be considered the result of just one of two motivational systems; appetite and aversion (Lang, Bradley and Cuthbert, 1997). These motivational systems can be said to affect the behaviour of primitive life forms (Schneirla, 1959). Humans have a great deal more goals and sub-goals, of course, and as such human emotional experience can appear much more complicated. Nevertheless, research has shown that these basic motivational systems can drive most if not all human emotional experiences. For example, in a study described by Lang (1995), participants were shown to display a startle reflex when viewing unpleasant stimuli (aversion), while the startle reflex was inhibited when viewing more pleasant images (appetite). It is this biological approach to emotion that has underpinned evolutionary theories of emotional experience. This strand of emotion theory could be said to stem from the work of Darwin (1872) and is the theory of emotion which predicts a degree of universality in emotional response and expression. From the evolutionary perspective, emotions can be seen as biological states which are elicited by internal and external stimuli, and which serve particular functions related to overcoming problems or finding solutions (see Cosmides and Tooby, 2000). Problems encountered by humans throughout evolution, such as the need to run or fight, may have been overcome with the aid of physiological changes induced by emotional states (see Levenson, 1992). Emotional responses can also be linked to adaptability in human perception and attention (Schupp et al., 2004). This links back to the previous discussion on one of the distinctions between emotion and mood, in which it was identified that emotion leads to action. Plutchik (1984) describes emotion-driven actions as adaptive behaviours, and relates these to specific emotional states. For instance, a stimulus such as a threat could trigger an emotional experience of fear, which in turn could lead to an adaptive behaviour driven by the need to escape.

It can be argued, however, that evolutionary theories of emotion dictate that emotional states are essentially universal biological responses – in other words, that particular stimuli will elicit particular emotional responses irrespective of individual cognition. An alternative set of theories of emotion stipulate that cognition is a fundamental component of emotion. Cognitive-appraisal theories of emotion – which stem from the work of Arnold (1960) and Schachter and Singer (1962) – place emphasis on the evaluation process. Rather than viewing emotion as a strictly automatic biological response which has emerged in modern humans through natural selection, appraisal theorists suggest that individuals will assess events, situations and other emotional stimuli (consciously or unconsciously) in order to determine which emotional response is appropriate (Frijda, 1986; Roseman, 1984; Scherer, 1999; Smith and Ellsworth, 1985). The underlying principle of appraisal theories is that specific emotions are not inevitably experienced as a result of a particular stimulus. Instead, individuals assess how a situation or event affects their goals and how they can cope with this stimulus. Through this cognitive process, specific emotional states will be evoked, but different individuals will experience different emotions when presented with the same stimuli.

Cognitive-appraisal theories typically constitute a series of criteria or dimensions that dictate how the process of appraisal is conducted, with variation in the nature and number of dimensions depending on the particular theory. The specifics of the dimensions of various proposed theories are not essential to the current research, but Scherer (1999) offers a comparison of different cognitive-appraisal theories, and also discusses why variation in appraisal dimensions exist (Scherer, 1997). The work of Scherer will be revisited shortly in order to investigate how a specific cognitive theory of emotion may inform animation production. It is important to note, however, that theories of emotion that feature cognition as a key component offer a basis for more complex models of emotional experience, which could ultimately be of use in focussed animation studies. The arousal model of interpersonal intimacy (Patterson, 1976), for instance, predicts that the intimacy behaviours displayed by an individual can trigger arousal in another involved person. The arousal change in the second person is then described as either a positive or negative emotion, with positive emotion likely to trigger continued arousal in both parties in the interpersonal exchange. With the arousal model, it is theorised that an emotional response can result from direct, intimate interaction with another person, and as such many other factors (e.g. the type of relationship or the setting) can impact on the nature and development of the positive or negative emotions. This takes the fundamental idea of aversion/appetite forward by declaring the nature of the emotional stimulus and incorporating contributing factors that are mediated by cognition.

In dealing with the animation of emotional expression, it is of the utmost importance that the underlying nature of emotional experience is well explored. As the above examples of evolutionary and cognitive-appraisal theories exemplify, this is by no means an easy task – the psychology and biology of human emotion is a vast research discipline, and a huge amount of theoretical and applied research has been conducted into the mechanics of affective states. It is therefore prudent that the focus is on particular frameworks and theories that specifically relate to basic emotional states, which would arguably be of most use to a study of emotional expression animation. In the following sections, Ekman's basic emotions and Scherer's computational process model of emotion shall be discussed. These two focussed discussions can be linked to evolutionary theories and cognitive-appraisal theories of emotion.

2.1.2.1 Ekman's proposal of basic emotion characteristics

From the evolutionary theory perspective, while it can be argued that there is evidence for basic emotion expression signals which are universal, the nature of fundamental emotional states is more difficult to determine. Even though there are adequate means of classifying or categorizing emotions, some researchers take a conservative stance, for instance:

> "…from a theoretical point of view, there appears to be no compelling reason to postulate basic emotions, regardless of the criteria used." (Averill, 1994, p 14).

Despite views such as this, the idea of basic emotions has been comprehensively addressed in psychology, albeit with variation in researcher points of view. Barrett (2006), for instance, takes the view that emotions can be seen as "conceptual acts". She argues that we make sense of our feelings by categorizing them based on our understanding of emotional concepts such as 'anger' or 'fear', but that the basic emotions themselves do not necessarily occur. Plutchik (1994), on the other hand, affirms that there are indeed a range of basic (or primary) emotions, but that these base emotions are effectively idealized states which may only exist hypothetically:

> "…emotions are seldom if ever found in a pure state. Any emotion has a complex history that has elements that go as far back as infancy. An emotion may have several different drive sources and may include a mixture of feelings and reactions."
> (Plutchik, 1994, p 39)

As Plutchik indicates above, the visual display on the face represents an inner emotional state which is truly complex. While studies of the universality of expression typically consider the appearance of discrete states – such as sadness or disgust – Plutchik takes the view that there are many more factors involved, and that naturally experienced emotions are unlikely to ever be “pure”. Complex emotional states could come about as a result of past experience or drives, as suggested by Plutchik. Drives could, for instance, be considered in terms of the effect of the temperament or mood of the person experiencing the emotion (as discussed earlier). Plutchik (1980) proposes a core eight primary emotions; fear, surprise, sadness, disgust, anger, anticipation, joy, and trust. From these primary emotions, emotions which are more or less intense can be derived, and combinations of two primary emotions can be described as primary dyads, as shown in Table 2.1. In other words, Plutchik’s view of basic emotions implies that the primary emotions can be manipulated in intensity or combined to create complex states. This model is broadly in line with the opinions of preeminent evolutionary theory emotional psychologists (for example, Ekman 1984; Izard, 1977, MacLean, 1993).

Table 2.1: Plutchik's (1980) concept of emotion relations.

Primary emotion	Stronger variant	Weaker variant	Primary dyad (when combined with a second primary emotion)
Joy	Ecstasy	Serenity	Love (Joy + Trust)
Trust	Admiration	Acceptance	Submission (Trust + Fear)
Fear	Terror	Apprehension	Awe (Fear + Surprise)
Surprise	Amazement	Distraction	Disapproval (Surprise + Sadness)
Sadness	Grief	Pensiveness	Remorse (Sadness + Disgust)
Disgust	Loathing	Boredom	Contempt (Disgust + Anger)
Anger	Rage	Annoyance	Aggression (Anger + Anticipation)
Anticipation	Vigilance	Interest	Optimism (Anticipation + Joy)

While Plutchik's model of emotional experience is clearly informative to the present study, the work of Ekman is perhaps of most direct relevance, particularly due to his associated work on expressions. As regards the definition of emotion, Ekman (1992) proposes firstly that basic emotions do exist and occur in isolation, and secondly that they can be defined by a range of nine characteristics which distinguish them from one another and from other affective states (such as mood or temperament). These distinguishing characteristics are summarized in Table 2.2. This table indicates that, if an affective state contains the nine characteristics described in the table, it is what Ekman would profess is a basic emotion. In Ekman's proposal (1992), he states that these nine characteristics apply to basic emotions of joy, sadness, anger, fear, disgust, and surprise, but that they may also apply to other discrete emotions such as contempt, shame, and guilt.

Table 2.2: Ekman's (1992) characteristics used to distinguish basic emotions from one another and from other affective states.

Characteristics	Distinct from other emotions	Distinct from other affective states
1. Distinctive universal signals	✓	✓
2. Presence in other primates		✓
3. Distinctive physiology	✓	✓
4. Distinctive universals in antecedent events	✓	✓
5. Coherence among emotional response		✓
6. Quick onset		✓
7. Brief duration		✓
8. Automatic appraisal		✓
9. Unbidden occurrence		✓

As regards these basic emotions, Ekman declares that his belief is that the "primary function of emotion is to mobilise the organism to deal quickly with important interpersonal encounters" (Ekman, 1992). He also draws attention to his previous affirmation that the basic emotions are not individual affective states, but families of related states (Ekman and Friesen, 1975). Within these families, variation in emotional state exists based on biology, experience, and the nature of the emotional stimulus. A breakdown of the nine characteristics is provided in Appendix II. By considering emotion in this way – as affective states defined by Ekman's clear categories (all of which have been or can be empirically assessed) – an emotional psychology framework for evaluating the animation of emotional experiences through facial expression can be proposed. There are of course other theories and concepts of emotional experience which must be considered. In general, Ekman (1992) and others such as Tomkins (1984) work to the principle that emotions are effectively limited, that evolution plays a pivotal role in emotional theory, and that the basic emotions can be aligned with universal signals, such as facial expression. As such, Ekman's proposal of basic emotion characteristics (underpinned by related work, such as Plutchik's models) was later used to inform studies of facial expression animation. Details of how Ekman's work was incorporated into the Emotional Avatars methodology are presented in Chapter 3.

2.1.2.2 Scherer's appraisal model

As well as Ekman and Plutchik's work on emotion from a purely evolutionary perspective, an alternative view on emotion cognition is offered by Scherer (1994) who defines emotion as a:

> "…sequence of interrelated, synchronized changes in the states of all organismic subsystems… in response to the evaluation of an external or internal stimulus event that is relevant to central concerns of the organism".
> (Scherer, 1994, p 25)

This distinction between emotions as discrete states and emotions as temporal patterns of changes amounts to a shift in our interpretation of emotion; not only of what an emotional experience is, but how it might be expressed. Although this relates to evolutionary theories in terms of the biology of emotion, cognitive appraisal theories focus on the development of emotions as a process of evaluation of events (e.g. Frijda, 1986; Roseman, 1984; Scherer, 1997, 1999). Scherer's appraisal model (Scherer, 1999) is examined here in order to demonstrate how appraisal theory can also inform animation evaluation. Scherer in particular is selected due to the fact that his work has been implemented in recent dynamic expression and computer animation research, for instance Wehrle et al. (2000), Malatesta, Raouzaiou and Kollias (2006) and Paleari and Lisetti (2006).

On the whole, appraisal theories consider the conscious or unconscious evaluation of a stimulus. This encompasses the positivity or negativity of an event, the potential for an event to block or assist one's goals, whether an event is a novel experience, whether or not the event can be controlled, and whether or not the event can be coped with. The evaluation checks of Scherer's appraisal model are depicted in Table 2.3. Although there is variation between (and within) theorists' proposed appraisal models, Scherer's model as shown below provides an insight into how the cognitive processes that occur when an emotion is induced may operate. For the novelty check, for instance, the suddenness of an event which evokes anger

Table 2.3: Scherer's (1999) appraisal model.

Sequential evaluation check	Considerations
Novelty	Suddenness Familiarity Predictability
Intrinsic pleasantness	
Goal significance	Concern relevance Outcome probability Expectation Conduciveness Urgency
Coping potential	Cause: agent Cause: motive Control Power Adjustment
Compatibility standards	External Internal

or fear is likely to be high, while for sadness the suddenness would likely be low. Whether an event is familiar or predictable could also relate to the emotional response. Here, anger and sadness would likely result from an unfamiliar event, and anger and fear from an unpredictable event. Despite variation in theory, the general concept of stages of sequential evaluation checks within Scherer's work can greatly inform animation practice and review. The animator can consider the novelty of the stimulus, the implications of the stimulus, how one can cope with the consequences of a stimulus, and how the stimulus fits with compatibility standards (in terms of social norms or personal concepts).

2.1.3 The universality of emotional facial expression

With a broad view of the nature of emotional experience established, the next area of research which is directly related to the Emotional Avatars project is the physical expressions of emotions. Among the first to examine in detail the appearance of facial expressions was Darwin (1872). Darwin considered both the anatomy of the human face and the biological driving forces that result in expressions of emotion in both humans and animals. A number of emotional states were discussed – including anxiety, joy, and disgust – although the discussion of such states were fairly generic (states such as 'low spirits' and 'high spirits') and the evidence was largely anecdotal. Within this anecdotal evidence, however, Darwin attempted to contextualise emotional states through personal experience. These early writings could suggest that emotional context is clearly important when it comes to

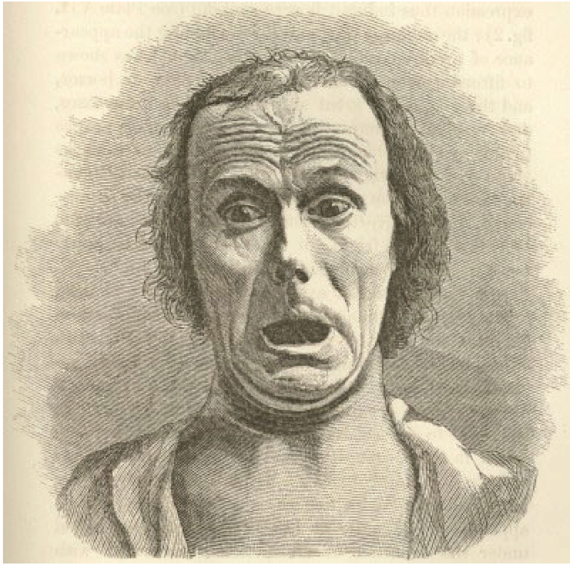


Figure 2.1: An expression of terror drawn from a photograph by Duchenne. Darwin (1872, p 299) used this image to illustrate the contraction of muscles down the sides of the neck, creating the wide mouthed expression of fear.

understanding both the emotional state of the person experiencing the emotion and the resulting facial expression. For instance, when describing the facial appearance of a low spirited person, Darwin stated that:

> "With respect to the eyebrows, they may occasionally be seen to assume an oblique position in persons suffering from deep dejection or anxiety; for instance, I have observed this movement in a mother whilst speaking about her sick son"
> (Darwin, 1872, p 180)

Darwin drew much from the work of Duchenne (1876), who investigated the contraction of individual facial muscles through the application of electrical currents (see Figure 2.1). As a result of Darwin and Duchenne's early exploratory studies of emotional expression, research into the nature of facial expression accelerated. Two main strands of facial expression research emerged – ethology (the scientific study of animal behaviour) and psychology (Russell and Fernández-Dols, 1997). In ethological research, the biological and evolutionary role of human facial expressions has been considered in detail (within the context of evolutionary theories of emotion, as discussed earlier). It has been purported, for instance, that the vocal calls of birds are parallel to the expression of emotion on human faces (Marler and Evans, 1997). This suggests an underlying evolutionary need for animals to express and communicate emotion. It is broadly accepted that evolution has played a part in the appearance of emotional expressions, as “nature has selected facial behaviour to maximise its communicative value” (Fernández-Dols and Ruiz-Belda, 1997). The similarities between the expressions of humans and other primates indicate that certain types of expressions have come about through evolution (Preuschoft and Van Hooff, 1995). The fundamental role of facial expressions as an evolutionary means of nonverbal communication has therefore led to the widely held belief that elements of some facial expressions of emotion are universal:

> "Considerable evidence exists that a small number of facial expressions, fear, anger, disgust, sadness, and enjoyment, are judged consistently in a wide range of cultures, including those having little or no contact with western societies."
> (Plutchik, 1994, p 175)

Darwin (1872) hinted at an element of universality in expression, but firmer conclusions based on empirical evidence emerged in the 1970s (Izard, 1971; Ekman, 1972). While the exact number and nature of universal expressions of emotion is debatable, the six expressions discussed by Ekman and Friesen (1975) are generally regarded as the core universal expressions;

Figure 2.2: The appearance of the six universal expressions of emotion. Taken from Ekman and Friesen (1975), the expressions of; (top row) anger, fear, disgust, (bottom row) surprise, happiness, and sadness.

happiness, sadness, anger, fear, disgust, and surprise (see Figure 2.2). Other emotions – such as contempt (Ekman and Heider, 1988) – have been put forward as potential universal expressions. Furthermore, it is argued that expressions of embarrassment, shame, and amusement could be recognized by observers as distinct expressions (Keltner, 2005). Social context is provided as a cause of these distinct expressions, with the author arguing that "individual's displays of embarrassment" are used to "appease observers of social transgressions" (Keltner, 2005, p 153). This finding alludes to the underlying social-evolutionary foundations of human facial expressions (social and cultural aspects of expressions shall be discussed shortly). Studies involving preliterate cultures (Ekman, 1972) added weight to the truly universal nature of emotional expression, and more recent studies using refined methodologies (Ekman, 1994b; Haidt and Keltner, 1999) have supplemented the already substantial evidence for universality. Furthermore, research has indicated that human observers can categorically identify and discriminate between fundamental expressions of emotion. Calder et al. (1996) demonstrated that happiness, anger, fear, and sadness can be discriminated by observers, replicating the earlier work of Etcoff and Magee (1992) which was based on line drawings of expressions. As such, there is an overwhelming amount of evidence to suggest that the core expressions highlighted by Ekman and Plutchik are indeed universal, in line with evolutionary-theories of emotion.

Perhaps the main point of contention with the standardised expressions (and which is particularly pertinent to a study of character performance) concerns the distinction between posed and genuine emotions. Rosenberg (2005) divides emotional expressions into two categories based on the underlying emotional experience of the person displaying the expression; spontaneous facial expressions (which are natural and felt) and deliberate facial expressions (which are posed). Spontaneous expressions are those which are closely linked to the evolutionary development of facial cues for conveying emotion, and which were observed and recorded by Darwin and other researchers in the field. Deliberate expressions, on the other hand, are staged interpretations of facial expressions based on our tacit understanding of spontaneous expression appearance. This latter category of expressions are often used in studies of facial expression, despite the fact that research has shown that variation in appearance and identification exists between spontaneous and deliberate expressions, even when skilled actors are used to simulate expressions using different acting methods (Gosselin et al., 2005). In this study, the nature of the emotional expression (whether the underlying emotion was felt or unfelt by actors) was shown to affect both the appearance and the identification of emotional expressions. Firstly, felt emotional expressions more closely resembled genuine, spontaneous expressions of emotion in terms of appearance. Secondly, observers were able to identify expressions of happiness, fear and sadness more readily when the emotion was felt, and expressions of anger and disgust more readily when the emotion was not felt (Gosselin et al., 2005, p 262). Happiness and surprise were two expressions which appear to be identified with a high degree of accuracy, regardless of whether the emotion is genuine or faked (Gosselin et al., 2005). In addition, deliberate and spontaneous expressions of emotion have been shown to differ in terms of onset and offset durations, as well as the number of phases (Hess and Kleck, 2005). This causes problems for studies which make use of purely posed expressions as stimuli in order to investigate the universality of expressions, and would indicate that either genuine expressions of emotion from nature or professionally acted spontaneous expressions ought to be used. In the case of the acted spontaneous expressions, the emotions must be truly experienced by the actors in order to synthesize expressions that are more representative of naturally occurring expressions – a case put forth by the Russian actor and theatre director Stanislavski (Stanislavski and Reynolds Hapgood, 2008) and confirmed by the research of Gosselin et al. (2005).

Studies of spontaneous expressions have shown that certain universal emotional expressions, such as disgust, can be reported by the participants experiencing the emotion, but not necessarily observed in the resulting facial expression when the expression is analysed using FACS[1] (Rosenberg and Ekman, 1994). A lack of coherence between self reported emotion and facial expression appearance has been demonstrated more broadly (Fernández-Dols et al., 1997). The apparent contradiction that emerges from these studies is that certain emotional expressions are put forth as being universal, and yet there is evidence to suggest that the relationship between felt emotion and facial display is not necessarily consistent. What this may lead to is a distinction between “optical truth” and “artistic truth” (Fernández-Dols and Ruiz-Belda, 1997). In other words, what people believe occurs on the face during expressions of emotion is re-enacted (as in acting or posing) or recreated (as in art), while what is actually displayed in nature is not as clear cut or easy to identify, and is likely to be mediated by cultural variation. What may exist, therefore, are two levels of universality; universality in terms of the natural communication and interpretation of emotion using a visual language rooted in evolutionary facial cues, and universality in terms of our innate ability to identify broad or standardised facial expressions which could well be elaborate interpretations of natural expression appearance. It is perhaps of no surprise that the visual language described in detail by Ekman and Friesen (1975) is therefore picked up by artistic practitioners (Faigin, 1990) who wish to communicate emotional expressions in their art cross-culturally and without ambiguity. While Ekman and Friesen’s work is strongly underpinned by empirical evidence that points to cultural universality in expression and perception (Ekman and Friesen, 1971), their descriptions and examples of expressions fit more with standardised expression appearances which are not

[1] The Facial Action Coding System (FACS), a system for analysing and describing facial movement developed by Ekman and Friesen (1978)

necessarily disrupted by cultural or individual deviation. Studies, such as that by Elfenbein et al. (2007), show that culturally specific ‘universal’ expressions may exist, and that people find it easier to recognize expressions when they contain their own cultural distinctiveness, even though standardised expressions (particularly the core six expressions) have been shown to be effective at communicating emotion cross culturally.

Despite variation in research findings, the prototypical expressions of happiness, sadness, anger, fear, disgust, and surprise described by Ekman and Friesen (1975) appear to be universally identified. Even if the expressions as described by Ekman and Friesen are closer to artistic truth than optical truth, their effectiveness is clear and their role in the Emotional Avatars project pivotal. However, before these universal expressions can be examined in more detail, it is prudent that the potential cultural and social effects on expressions are first taken into account.

2.1.3.1 Cultural factors which modulate expression

Earlier, two strands of emotion theories were discussed; evolutionary theories, and cognitive-appraisal theories. A third strand of emotion theories – social-constructionist theories – concerns the role of culture and learned behaviours in experiencing and communicating emotion (Harré, 1986). In opposition to evolutionary theories which place emphasis on the biological source of emotion, constructionist theorists tend to indicate that our ideas of emotion stem from human culture. This perspective on emotion impacts on the idea of basic emotions, which are dismissed by Averill (1994). Ekman

(1989) reviews some of the most prominent research which sought to find cultural differences in facial expression and, for those that did find differences, states that the differences that do exist do not negate from the universality of the core expressions. Ekman also addresses the work of leading constructionist theorists who put forth ideas that expression is wholly dictated by culture (Mead, 1975) and that facial displays are a form of culturally learned language (Birdwhistell, 1970). Ekman (1989) counters these arguments by drawing attention to the existence of cultural variation in terms of learned display rules and by highlighting the wealth of evidence which points to evolutionary universality.

There are some interesting examples of cultural variance that are worth noting. As regards the specific components of facial expressions which universally communicate the nature of an experienced emotion, research has shown that smiling or raised brows can be broadly interpreted as ‘happiness’, while non-smiling or lowered brows can be interpreted as ‘dominant’ (Keating et al., 1981). However, this research also indicated a degree of cultural variability in interpretation. Smiling in general is seen as a contentious issue in universality, with arguments on the side of constructionist theory pointing to the appearance of smiles when unpleasant emotions are felt (see Ekman, 1989). As Ekman indicates, however, smiles should not be considered synonymous with feelings of happiness or amusement, as smiling expressions can occur in different circumstances and for different reasons (Ekman and Friesen, 1976). Cultural variation in smiling can also be related to the effect of culturally learned display rules (Ekman, 1989). Elfenbein et al. (2007) reported more specific cultural differences in both the expression and recognition of emotional facial expressions. In their study of Canadian (Quebecois) and Gabonese participants, they found that regional differences occurred most prominently in the expression serenity, shame and contempt, less so in anger, surprise, sadness, and happiness, but not at all in fear, disgust, or embarrassment. The differences were observed using FACS (Ekman and Friesen, 1978), with the analysis highlighting the fact that the two groups would activate different muscle groups for some expressions. For instance, the Quebecois participants more frequently lowered their brows during expressions of contempt than did the Gabonese participants. Furthermore, it was shown that the participants found it easier to identify emotions which incorporated their regional 'dialects' than more standardised 'universal' versions of the expressions. Again, these variations could be attributed to culturally learned control over universal expressions. The existence of display rules within specific cultures was famously reported by Friesen (1972), who discovered that American and Japanese participants would both display recognizable and similar expressions of disgust when observing unpleasant film footage. Afterwards, when discussing their experience with an interviewer, the Japanese participants were seen to display smiles, while the American participants continued to convey more negative expressions. The likely reason for this is a Japanese cultural trait which involves using a smile to mask negative emotion (Ramsey, 1984).

It can be argued that studies such as those presented above can throw some doubt on the comprehensive universality of complete emotional expressions in nature. Cultural variation most certainly exists, but the evidence would indicate that this variation exists as differences in learned behaviours in terms of modulating and controlling the natural (universal) expressions of emotion in order to address regional sensibilities or social rules. As such, Ekman and Friesen's (1975) examples of what are, in effect, standardised expressions, continue to be accepted as a general guide to the core expressions of happiness, sadness, anger, fear, disgust, and surprise. For the purposes of the Emotional Avatars research, the impact of cultural variation was therefore a consideration when evaluating the animation of choreographed expressions, but cultural differences were not planned for or built into the animation for the current research.

2.1.3.2 Social factors which modulate expression

The case for universality in the facial expression of emotional experience is strong, as has been shown. However, the impact of other affective states and factors on facial expression has also been examined. For instance, it has been suggested that complex states, not just basic emotions, can be categorised as types of facial expressions (Baron-Cohen, Wheelwright, and Jolliffe, 1997). In terms of personality, it has been shown that types of emotional expression can infer personality traits (Knutson, 1996), and that facial symmetry can be linked to personality type (Fink et al., 2005). More remarkably perhaps, it has been demonstrated that observation of facial actions and expressions can in fact affect perception of personality (Arya et al., 2006). The fact that personality or temperament may be perceived within discrete emotional expressions should be taken into account by any study of expression animation, as the appearance of animated features within expressions may inadvertently infer personality in addition to emotion. There have been efforts to identify the core components of expressions in order to analyse the movement and propose cognitive processes. While FACS sought to break down the face into the essential muscle movements, frameworks have been suggested that link nuanced facial movement to underlying meaning (Smith and Scott, 1997). However, not only is it difficult to attribute specific movements with thoughts and feelings, but it is also true that observers can interpret actions in different ways. As such, the overall context of an emotion can be put forward as being a significant factor in the expression or interpretation of emotion through facial displays:

> "…an observer can recognise not only sadness in crying but also happiness, not only anger in frowns but also puzzlement, and not only happiness in smiles but also amusement or social invitation."
> (Fernández-Dols and Carrol, 1997, p 289)

This point is particularly important to the animation practitioner, and so the context (in terms of the character, narrative, or situation) ought to be raised as a key factor when animating and observing emotional expressions. In addition to these potentially subconscious factors which affect emotional expression appearance, it has been argued that we exercise more deliberate control over facial expressions:

> "One's awareness and control of facial reactions…is probably greater than that of other nonverbal behaviours. As a result, facial responses seem to be more easily managed, and consequently more important in attempted deception."
> (Patterson, 1983, p 55)

Our control over expression appearance may, for instance, be driven by the desire not to expose our true emotional state, particularly so if the emotion is negative:

> "…there are considerable restraints on the expression of negative attitudes or emotions, so that spontaneous expressions are often concealed."
> (Argyle, 1972, p 249)

This 'masking' of emotion might be in the form of voluntary control over facial features, such as the holding back of a smile while experiencing happiness. The suppression of emotional expressions such as sadness and anger has been linked to a desire to avoid negative interpersonal interaction (Zeman and Garver, 1996), and individuals may choose to display or limit expressions dependent on who else is present (e.g. peers, parents etc). In addition, gender and temperament may affect an individual's use of display rules (Underwood, Coie, and Herbsman, 1992). The effect of masking on dynamic emotional expressions has shown that the duration of observation could be the key to accurate identification of expressions which are masked (Esteves and Arne, 1993). As well as expression suppression, masking can involve the appearance of a false emotional emblem which is used to disguise the true emotional experience. For example, Ansfield (2007) described the appearance of a smile when participants became distressed. Not only was this an act of self regulation, but observers also indicated that these smiles were socially inappropriate. As far as masking or dishonest emotional displays are concerned, the role of smiles in different contexts has been researched extensively. It was proposed that felt happy smiles (where the emotion is genuinely experienced by the person expressing the smile) would have a consistent appearance, with the “zygomatic major pulling the lip corners upwards towards the cheekbone” and the orbicularis oculi raising the “cheek and gathering the skin inwards from around the eye socket” (Ekman and Friesen, 1982, p 242). This type of smile is commonly referred to as the Duchenne smile, and it has been shown to occur under controlled conditions. In one study, when genuine happiness was experienced, there was more “activity of the outer muscle that orbits the eye… than when enjoyment was feigned” (Ekman et al., 2005, p 209). Additionally, the emergence of Duchenne smiles has been investigated in terms of social context, with one such example being research into the appearance of infant smiles when interacting with their mothers (Messinger et al., 2001). In this study, activity around the eyes was shown to occur shortly after the smile in a range of cases. However, despite the Duchenne smile being presented as one of the clearest examples of a truthful emotional display in nature, other studies have concluded that observers have more trouble discriminating between Duchenne and non-Duchenne smiles when they are asked to rate how genuine the emotions are (Krumhuber and Manstead, 2009). As such, it is possible that humans have inherent variation in emotional expression display dependent on the nature of the felt emotion, but that the subtlety of these differences are difficult for observers to detect.

Overall, then, while expression universality – at least in terms of full blown and prototypical expressions – is clearly a fact, there are also a range of social and individual factors which can impact on both the appearance and interpretation of these expressions. Going forward, the role of personality and temperament, display rules, cognitive process, and context are essential to animation production and analysis. At the base level, however, the core emotions of happiness, sadness, anger, fear, disgust, and surprise have unmistakable natural expressions which must be well understood.

2.1.3.3 The experience and expression of the universal emotions

Much has been written about the physiology and psychology of the six basic emotions, as well as the physical appearance of associated facial expressions. As this work underpins the production and assessment of facial expression animation, an overview of the key literature on the nature and appearance of happiness, sadness, anger, fear, disgust, and surprise is included in Appendix III. From this review, it is clear that any facial animation set up must have a high degree of flexibility across the brows, eyes, and lower face, as well as scope for movement of the head, gaze direction, and facial wrinkling. Essentially, an accurate model with realistic musculature and capacity for either creasing the surface or modulating its appearance through shader techniques is crucial to any focussed study of expression animation. The development of a facial rig to meet the needs of the universal expressions is discussed in Chapter 4.

2.1.4 Applying emotional psychology to animation production

Even before the facial expression of emotion is considered, emotional experience – a biological response modulated by a wide range of social, cultural, contextual, and individual factors – is a complex theoretical construct. Beyond the underlying experience of emotion, the movement of the face is particularly intricate, and the relationship between facial dynamics and character experience can be an enormously tricky issue for animators. Being aware of every facet of emotional psychology and facial anatomy is clearly not practical for animators, although a good knowledge of both areas would certainly underpin animation practice. The incorporation of the universal expressions and FACS into art practice and animation is not a novel concept. Indeed, this overlap between scientific inquiry and arts practice is well established in associated literature and animation guides (e.g. Faigin, 1990; Osipa, 2007). Nevertheless, to date no art-led research project has sought to involve the more complicated emotional theories in studies of expression animation. While computer science research has embraced emotional theories and models in order to develop advanced artificial intelligence and embodied agents (which shall be discussed later), it would seem wholly appropriate for a practice-led study of facial expressions to be underpinned by strong psychology research.

Throughout this section, related emotional psychology research which is of direct relevance to the appearance of emotional expressions has been summarised. From this overview, Ekman's description of the basic emotions stands out as a comprehensive theory of emotion which could be used by an animator to frame his or her practice. Additional related research discussed in this section – including Scherer's work on cognitive appraisal, Plutchik's work on emotion, and research into social and cultural effects – can be directly linked to one or more elements of Ekman's basic emotions manifesto. As such, the detailed descriptions of basic emotion attributes offered by Ekman could be embraced by an animation practitioner-researcher in order to inform studies of emotional expression animation, ensuring that theories of emotional psychology play a role in the proposed art-based research of the Emotional Avatars project. However, the related work on emotional psychology can only provide a platform for the proposed animation research. As the aim of the Emotional Avatars project is to learn about dynamic emotional expressions through animation practice, it is important to look at how this creative activity can be embraced as a method of formal research, and also to show how knowledge arising from practice offers a different perspective from typical scientific methodologies.

2.2 The artistic perspective: research through animation practice

Formal research in the visual arts is an emergent field. Practitioner-researchers are rapidly becoming empowered with the confidence to conduct research *through* their practice (rather than *into* their practice), a fact that is reflected in recent publications regarding visual arts research methods (Barrett and Bolt, 2009; Elkins, 2009a; Gray and Malins, 2004; Sullivan, 2009). The theoretical frameworks and methodologies of visual arts research shall be discussed in detail in Chapter 3, but for now it is important to consider research which has been conducted through artistic practice, and to discuss how this may relate to the Emotional Avatars agenda. While most animation research is still very much rooted in film criticism, the recent commencement of a practice-orientated animation research journal (Wells,

2011) highlights both the acceptance of practice as a method of research, and the desire of animation practitioners to disseminate their findings. In the following sections, the potential for animation practice to act as a catalyst for knowledge generation shall be explored, and the current arts-derived knowledge of character and facial animation examined.

2.2.1 Thomas and Johnston's principles of animation

By far the most well known taxonomy of knowledge to arise from animation practice are the principles of animation. Developed in the early days of the Disney studio, the twelve core principles of animation have endured for the best part of a century, to the point where they are considered fundamental to the practice and theory of animation in the broadest sense; not just to cell animation, but to stop motion, cut-out, Flash, and 3D animation. In this respect, an understanding of the principles is truly central to the Emotional Avatars project, as the art of expression animation is effectively guided by these principles. The story of how the principles of animation came to be also illustrates how studio-practice and iterative artistic experimentation can drive the generation of knowledge – an idea that goes some way towards vindicating the notion of animation practice as research. As such, discussion of the principles of animation is critical to the Emotional Avatars project.

Thomas and Johnston's (1981) reflective and insightful discussion of their days at the Disney studio contains the first extensive description of the principles of animation. Their introduction to how the principles came to be alludes to the kind of cutting edge, experimental work the Disney animators were conducting at the time:

> "The animators continued to search for better methods of relating drawings to each other and had found a few ways that seemed to produce a predictable result. They could not expect success every time, but these special techniques of drawing a character in motion did offer some security. As each of these processes acquired a name, it was analyzed and perfected and talked about, and when new artists joined the staff they were taught these practices as if they were the rules of the trade."
> (Thomas and Johnston, 1981, p 47)

A lot can be drawn from the above quote when it is considered in the context of formal research methodologies. Firstly, it is clear that the Disney animators saw themselves as researchers, in that they were working at the edge of existing knowledge with the aim of developing better methods for conducting their practice. The authors state that, as methods were refined, the results of those methods became more and more predictable – so these animators were obviously seeking to anticipate the outcome of particular techniques. In essence, the early Disney animators had established a systematic and cyclic research methodology with the aim of perfecting their practice. Part of this process involved holistic analysis of results and collaboration between practitioners to draw conclusions. Eventually, a set of principles were established that would underpin animation practice for generations to come. The story of the principles of animation is a story of formal research framed not by the scientific method, but by artistic, reflective practice. This approach to practice-based research through animation production continued to generate further insights into the nature of the

Table 2.4: The twelve principles of animation as described by Thomas and Johnston (1981).

1	Squash and Stretch
2	Anticipation
3	Staging
4	Straight Ahead Action and Pose to Pose
5	Follow Through and Overlapping Action
6	Slow In and Slow Out
7	Arcs
8	Secondary Action
9	Timing
10	Exaggeration
11	Solid Drawing
12	Appeal

principles long after the golden age of the Disney studio; for instance, the refinement of the principles of animation as applied to 3D animated films (Lasseter, 1987). In this sense, the evidence would indicate that practice-based studies of facial expression animation could be used to generate a new understanding of how these complex movements may be animated. An overview of practice-based research methodologies is presented in Chapter 3. Firstly, the core principles of animation (see Table 2.4) must be considered in the context of practice-based studies of facial expression. While all of the principles are crucial to successful animation, some are of particular importance to the production and evaluation of emotional facial expression animation within the Emotional Avatars remit.

Squash and Stretch is described by Thomas and Johnston as the most important finding in the development of the principles. Simply put, this principle stipulates that fleshy materials should not move in a rigid fashion; that the movements of objects like arms and legs should be ‘squashed’ when impacted and ‘stretched’ when moving with speed or rebounding. Creative application of the Squash and Stretch principle can be used to push the boundaries of natural realism, creating ever-more eccentric deformations. In the context of facial animation production, the fact that the face is made of soft tissue makes Squash and Stretch a crucial consideration when conducting practice-based studies of expression movement. Here, experimentation with the shape of the face during expressions – particularly the mouth and cheeks – must adhere to the Squash and Stretch principle in order to produce movements that appear lifelike. Anticipation is again rooted in a natural occurrence – the observation that a leading action typically precedes a main action (for instance, pulling a tennis racquet back before smashing a tennis ball). The purpose of Anticipation in animation is to address the risk that the audience may miss an action if they are not adequately prepared for it. Anticipation in facial expression animation is essential, not only to prepare the audience for a shift in expression, but also to ensure that subtle movements are noticed. This concept links directly to the principle of Staging, which ultimately dictates that any idea presented to an audience must be completely unambiguous. Although Staging can be applied broadly across all elements of an animated scene, in the context of facial animation appropriate attention must be given to Staging to ensure that any expression, no matter how subtle, is presented with absolute clarity. To an extent, this poses a conflict of interests between realistic occurrences of expressions (i.e. naturalistic expressions may become difficult to read due to the range of factors discussed earlier in the chapter) and the necessity of clear communication with the audience. The expression animator therefore faces the conundrum of imitating the complexity of nature, yet simplifying and drawing attention to a core idea without breaking that suspension of disbelief.

Follow Through (the idea that appendages or other elements of a character should continue to move after that main body has come to a halt) and Overlapping Action (the offsetting of parts of an animated character) are both fundamental to effective facial animation. For instance, the fleshy lower face may continue to move after the peak expression of surprise, with the head and eyes are already locked into a held pose. Once again this principle has roots in natural movement, but implies poetic license to modify movements for maximum effect. Slow In and Slow Out, the principle which forces consideration of the acceleration and deceleration of objects as they move between poses, applies to movements between expressions – particularly within regions of the face. As stipulated by this principle, all movements between expressions ought to have slower movements near the key poses to adequately imitate realistic motion. Close observation of natural expression movement and creative experimentation with the principle of Slow In and Slow Out therefore plays a major role in successful expression animation. In order to experiment with the speed of movement between expressional poses, the principle of Timing must be considered. Traditionally associated with the number of drawings used, Timing is a crucial idea which guides the allocation of frames between two poses. It is Timing which ultimately aids an animator when he or she is looking to determine how fast an expression of surprise should move, or how slow an expression of sadness should emerge, without compromising the believability of these naturally occurring expressions. Secondary Action – the animation of additional movements to support primary actions – plays a key role in the animation of expressions. For example, the primary action in an animation of happiness would likely be the smile. However, research discussed earlier highlighted the role of the eyes region in genuine (or Duchenne) happy expressions. The wrinkling of the eyes may be considered the Secondary Action, supporting the smile to make the overall expression clear and authentic.

Finally, Exaggeration is the principle which is perhaps most clearly associated with animation, particularly animation in the cartoon tradition. Thomas and Johnston provide an anecdote of Walt Disney's view of 'realism', stating that "when Walt asked for realism, he wanted a caricature of realism" (1981, pp.65-66). Essentially, the principle of Exaggeration relates directly to the title of Thomas and Johnston's book – it is about creating the illusion of life, and oftentimes the most believable illusion is not an accurate reproduction but an exaggeration of a movement or idea. In facial animation, an exaggeration of anger, carefully controlled and experimented with, could potentially appear more authentic than an accurately captured animation of naturalistic anger. Exaggeration is all about pushing the limits of movement and velocity, and can be used to enhance the effect of many of the other principles. Application of Exaggeration along with the other principles should, in the right hands, result in facial animation that is believable yet not strictly natural. Essentially, practice-based research into facial expressions will lead to animations that are artistic imitations, rather than accurate replications, of life.

However, it is here where an apparent contradiction between the principles of animation and the actions of animation researchers emerges. Despite the fact that the principles of animation promote the creative distortion of reality to produce a higher level of realism, animation practitioners and researchers have shown a keen interest in capturing reality as accurately as possible. Undoubtedly the principles of animation are a tried and tested formula for successful character animation, and the relevance of the majority of these principles to the Emotional Avatars research is clear. Nevertheless, the ambition to replicate the exact movement of actors in animation is an important issue to address; why, for instance, should practice-based studies of facial animation reveal insights that performance capture could not? This aspect of animation research must be explored in order to fully understand why the principles of animation can overrule even the most accurate capture of natural reality.

2.2.2 The animator’s ambition to capture life, and the uncanny valley

As the principles of animation suggest, the animator’s take on human perception is quite different to that of the positivist researcher, who is primarily interested in the collection of empirical, objectively obtained evidence. The rigorous scientific methods used in positivist research minimise the effects of human intervention and observation on the objectivity of the data, which in turn allows researchers to make generalizations regarding human perception based on statistical probability. While this is as objective an approach a researcher can take, the dominance of the positivist perspective in formal research does not automatically invalidate the animator’s artistic research perspective, nor does it imply that his or her understanding of human perception and interpretation is lacking in evidence. The difference between positivist and arts-based animation research is epistemological: the evidence that animators make use of emerges from a more direct and interactive form of research, one which is practice-based and reflexive. Practice-based animation research – as subjective and open to human manipulation as it is – can have clear and practical outcomes. As discussed previously, without practice-based experimentation in animation, the very principles which are now used to create animation would not exist. Furthermore, the practice-based research of animators has gone hand in hand with development of innovative technology:

> "Virtually all forms of animation… have been predicated on experimentation in one form or another and certainly have been in the continual embrace of technological progress."
> (Wells, 2002, p 31)

One such technological innovation that enabled early animators to study and mimic lifelike emotion is known as 'rotoscoping' – a technique which allows animators to copy live movement by tracing from film. This method was developed and patented by Max Fleischer (see Figure 2.3), who was initially tasked with finding "some way to make animated cartoons look better, smoother, more lifelike" (Fleischer, 2005, p 15). Rotoscoping is essentially the original 'motion capture' method used by animators to create cartoons based on acted performances, and was used by the Fleischer studio to produce some of their most popular cartoons. On viewing the first animated cartoon produced using the rotoscope, Fleischer and his brothers marvelled at their accomplishment:

"… a cartoon that moved as no other cartoon had ever moved before, a cartoon clown that walked, ran, jumped, and danced with completely lifelike motion. The little clown was purely and utterly and delightfully human. It was alive. It was magic."
(Fleischer, 2005, p 21)

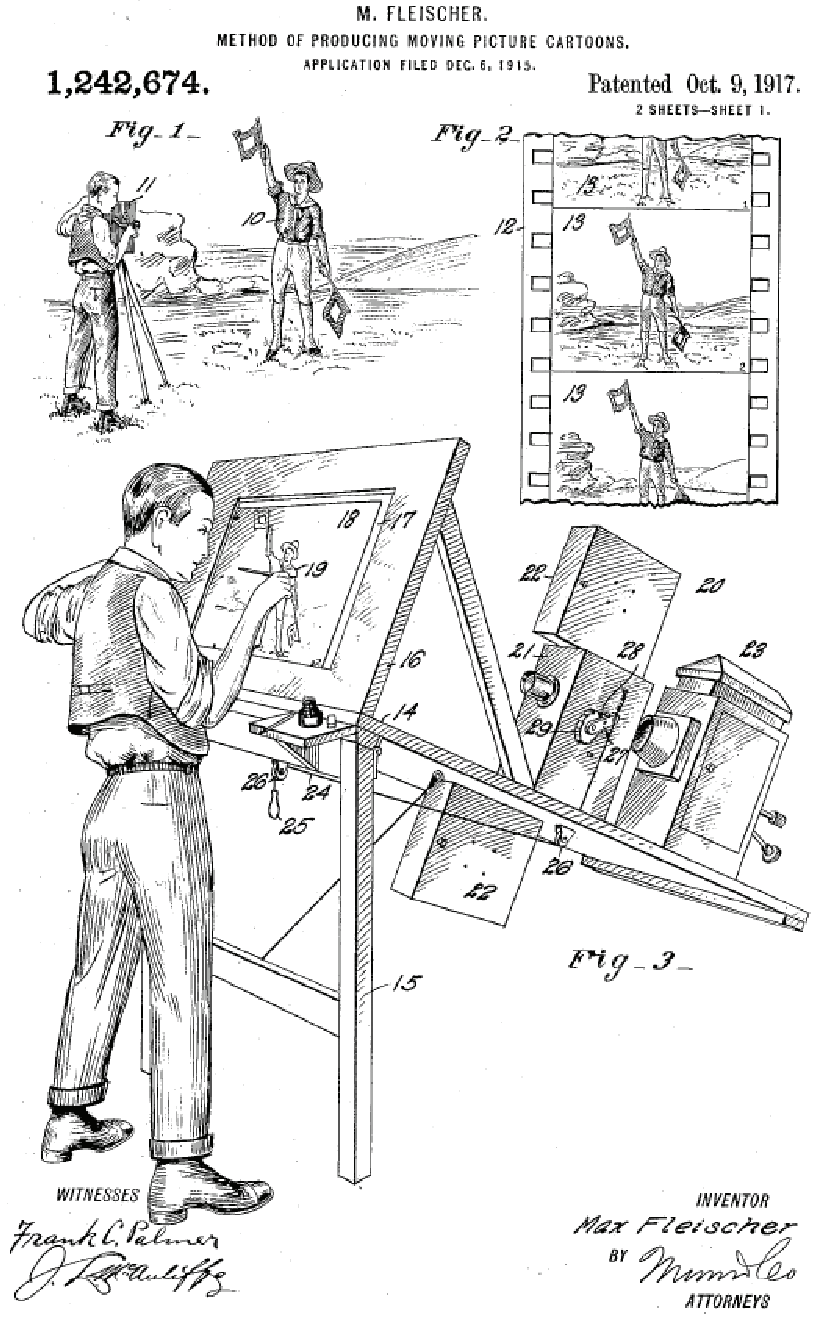


Figure 2.3: Images from the patent submission by Max Fleischer for the design of the Method of Producing Moving Picture Cartoons, more commonly known as rotoscoping (Fleischer, 1917).

Rotoscoping continues to be used as a distinctive method for producing animation today, with one of the most notable full-length features of recent years to incorporate the technique being *A Scanner Darkly* (2006). However, even in the early days of industrial animation production, problems with the rotoscope approach were clear. Although the method in itself proved enormously useful when it came to studying and mimicking movement from life, it seemed that complete replication of physical movement in animation was troublesome. At Disney, it was noted that direct copies of 'photostats'[1] resulted in animation that looked "very strange" and that the animated figure, traced from real life performance, had "lost the illusion of life" (Thomas and Johnston, 1981, p 323). This unexpected phenomenon – that animation could appear less lifelike even though it is a more direct copy of life – is explained by Thomas and Johnston:

> "No one knows for sure why a pencil tracing of a live action figure should look so stiff and unnatural on the screen, unless there is no reality in a copy… The camera certainly records what is there, but it records *everything* that is there, with an impartial lack of emphasis. On the other hand, an artist shows what he sees is there, especially that which might not be perceived by others. His drawings can be closer to the true realism of an object because he can be selective and personal in what he chooses to show."
> (Thomas and Johnston, 1981, p 323)

This point is expanded upon by Hooks, who notes that rotoscoping by definition is "a second-generation performance" (Hooks, 2000, p 87). Hooks goes on to stress that physical movement (which can be lacking in intention) and acted performances are very different things. Essentially, rotoscoping, as

[1] Photostats were film stills printed out on to photographic paper the same size as the animator's drawing paper and used as a guide (Thomas and Johnston, 1981).

a method of capturing physical movement for 2D animation production, is effective as a reference or as a guide but not necessarily as a means of copying reality in order to produce lifelike animation. As Thomas and Johnston argue, the key to lifelike animation based on filmed performance is for the animator (as an artist) to interpret the movement of the actor, to consider the guiding principles of animation, to focus in on the key movements that will become the dominant actions, and to create original animation that has both “clarity and vitality” (Thomas and Johnston, 1981, p 323).

Over the course of the last decade, traditional rotoscoping has been superseded by automated means of recording acted performance and using the data to drive animated characters. This technology is often termed motion or performance capture. Like rotoscoping, the technological innovation and experimentation which has underpinned the development of performance capture is rooted in practice-research. One of the earliest examples of the application of this technology in popular cinema was the performance capture of actor Andy Serkis to drive the 3D animation of the character Gollum in *the Lord of the Rings: the Two Towers* (2002). Technologically, this was a complex undertaking for the film’s production team, and involved the real time capture of the actor’s performance of a human-like – but ultimately inhuman - character (see Figure 2.4). The animation of Gollum, however, did not end with Serkis’s captured performance – animators were crucial to the post-production process (Scott, 2003), and over 10,000 blend shapes had to be produced throughout the development of the character (Lewis et al., 2005). While the final animated performance of Gollum in the *Lord of the Rings* films was met with praise, other examples of performance capture have not faired as well. *Beowulf* (2007), for instance, was lambasted by some critics who raised concerns about "the aesthetic efficacy of performance-capture technology" (Forni, 2009, p 47). *The Polar Express* (2004) in particular drew criticism for the eeriness of the character animation and apparent uncanny valley effects (Brinsmead, 2008; Geller, 2008). One possible explanation for the perceptual problems inherent in performance capture may be that it is typically applied to virtual humans, and that it is the motion captured animation of realistic humans which we find unnerving:

> "One reason Gollum was so successful is that he has big eyes, and the shape of his face is not quite human. Grendel in Beowulf is also disfigured and deformed. The audience subconsciously says, 'He's not human; I don't have to judge him by the same rules as if he were.' But when we try to portray a human, viewers notice what's missing."
> (McDonald cited in Geller, 2008, pp.12-13)

Figure 2.4: Andy Serkis's performance of the character Gollum for the film the Lord of the Rings: the Two Towers (Scott, 2003).

The eerie quality of hyper-realistic animation has often been likened to Mori's (1970) uncanny valley hypothesis: the theory that, as robots take on more human-like characteristics, we find them increasingly familiar, but only up until a certain point. The 'valley' of the uncanny valley hypothesis is the point at which there comes a dip in familiarity – the point at which the robot becomes *too* human-like, and the point at which it becomes 'uncanny' (see Figure 2.5). It has been suggested that the uncanny valley of robotics could also apply to virtual characters (Brenton et al., 2005). This hypothesis has been used to frame research into audience perception of animation, comparing hyper-real animation to the more cartoon-like animation of Disney Pixar and Dreamworks. Butler and Joschko compare the hyper-real animation of *Final Fantasy: the Spirits Within* (2001) to Pixar's *the Incredibles* (2004), and conclude that "ultra-realistic 3D animations provide audiences with limited opportunities to employ their imagination and to generate strong emotional interaction with characters" (Butler and Joschko, 2007). Their paper indicates that the "animated version of reality needs to remain sufficiently abstract" in order achieve this connection between characters and audiences.

Empirical research into the uncanny valley has, to a degree, vindicated this position. MacDorman et al. (2008) describe how the uncanny valley may not be as straightforward as suggesting that more human-like characters appear uncanny. Instead, the effect could be a result of a mismatch between human-like and unfamiliar elements (e.g. large eyes, unnatural motion, etc). This proposition is backed up by their findings, which demonstrated that unnatural features appeared more disturbing on photorealistic faces than on

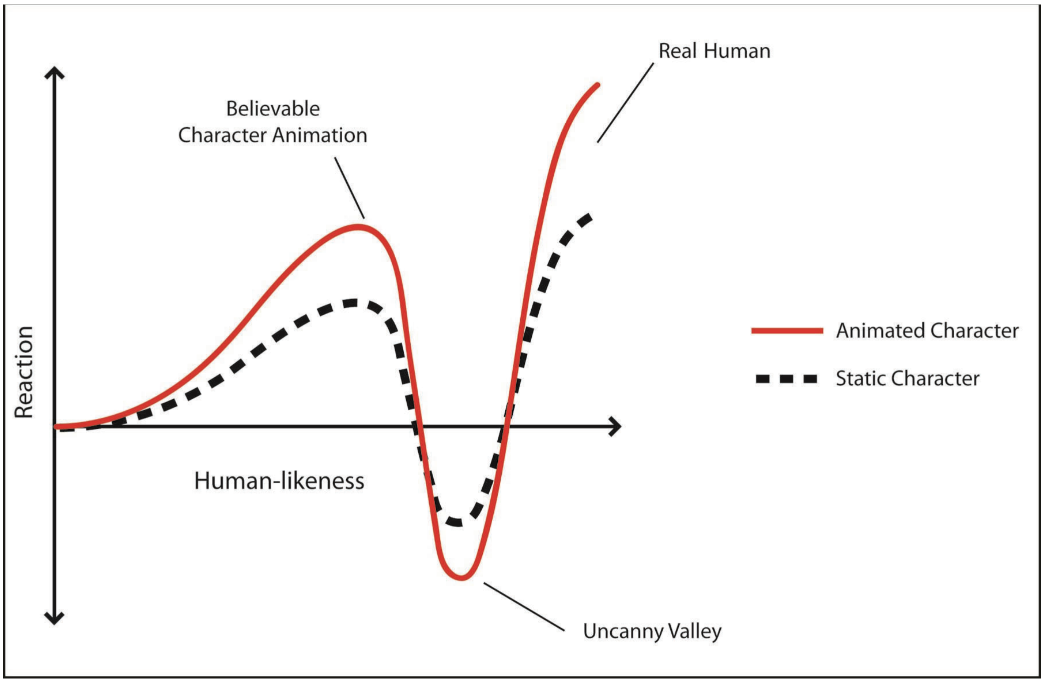


Figure 2.5: Audience reaction to animated characters on a scale of human-likeness, based on the uncanny valley theory proposed by Mori (1970).

alternatives. In the context of animation, hyper-real performance captured characters run a high risk of appearing unbelievable, and thus the replication of life in *the Polar Express* and *Beowulf* is less lifelike than the artistically produced animation of the Pixar studio. Furthermore, it has been suggested that the uncanny valley could actually be better interpreted as an 'uncanny cliff'. Bartneck et al. (2007) measured observer responses to photographs of humans and robots with four conditions (human, manipulated human, computer graphics, and android) and concluded that:

> "The uncanny valley appears to be more of a cliff than a valley since even pictures of humans do not reach the level of pictures of toy robots. It has to be acknowledged that there is a small upwards trend again towards highly human-like entities, which results in a small valley. However, the most dominant feature in the graph is not the valley, but the cliff preceding it."
> (Bartneck et al., 2007, p 372)

In this re-interpretation of the uncanny valley, the research conducted by Bartneck et al. shows that man-made characters can be regarded more positively than photographs of humans. By this logic, it is clear that artistically crafted animated characters can in fact be more emotionally engaging than not only performance-captured hyper-real characters, but even photography and film of real humans. The emotional impact experienced by adult audiences of *Toy Story 3* (2010) would appear to support this claim (Rohrer, 2010). This in itself would not necessarily be met with astonishment by animators, who are trained to produce moving characters that audiences find not only believable, but engaging and emotionally evocative. It is also not surprising when compared with the point made earlier regarding Thomas and Johnston's (1981) view on the lack of artistry involved in strict rotoscoping. It is, however, a point that is well worth noting when it comes to current research in computer animation, where trends in research point towards an ever-increasing level of captured reality contained within computer animated characters. While technological innovations such as rotoscoping and performance capture are undoubtedly tools which can be used to animate *realistic* characters, it is plain that artistic intervention is still key to the animation of *believable* characters. In this sense, the proposed investigation of facial animation performance must be firmly rooted in the principles of animation and artistic practice, with the technology for producing computer animation playing a supporting rather than leading role. Research into performance capture may result in technological advance, but the aim of the Emotional Avatars project is to reveal an artistic understanding of what can make animated emotional expressions *more* real than reality. This can only be framed by the principles of animation; the very principles developed by the Disney studio to realise Walt's dream of creating a believable illusion of life.

2.2.3 Animating facial performances

Since the dawn of principles-driven character animation, the matter of creating believable, dynamic facial expressions has been at the forefront of practitioner's minds. Thomas and Johnston (1981) provide an overview of how expressions may be treated in order to maximise their readability and impact, with particular emphasis on the eyes. Indeed, the eyes and brows, as the cliché goes, are the windows to the soul – and this point is certainly not lost in animation practice. The primary concern for the character animator when creating facial expressions is not to imitate what psychology research tells us (i.e. what a fearful or sad expression looks like). The primary concern is to expose the soul of the character; an aim so subjective and driven by reflexivity that performance capture as a method is inadequate in comparison to application of the principles. Broadly speaking, the soul of a character can be equated to the thought-process, which takes precedence over the (arguably) more simplistic notion of expressed emotion. Hooks (2000) ranks the role of thinking and emotion in animation as his first of seven essential acting concepts. Using his suggested approach, animators should look to develop the brain, not just the heart, of a character. From Hooks's perspective, it is the perceived brain (thought process) of characters that make us care about them, and it is thinking that is the precursor to emotion:

> "We are all different, but all of us have certain traits in common. We all think, and we all experience emotions. Emotions come from thinking."
> (Hooks, 2000, p 3)

This concept sits apart somewhat from the theoretical nature of emotion discussed by Ekman (1992), who favoured the role automatic appraisal and distinguishes emotion as a fleeting affective state that is unbidden. It is, however, reminiscent of the concepts of cognitive appraisal, and can be related to ideas such as emotion regulation and expression control. While the emotional psychology research on the matter is enormously complex, animation practitioners typically show more concern for the principles of animation, where ideas such as Staging and Exaggeration dictate absolute clarity and caricature overrules nature. Just like the selective use of line and shape when 'copying' filmed movements using a rotoscope, the animator ought to be selective in the application of psychology to his or her practice, and must not allow the complex (and potentially unknowable) subtleties of nature dampen the impact and Appeal of an animated facial performance. Facial animation production therefore places a high degree of importance on the visual appearance of thought process, which precedes all animated emotional responses. And thought process through the upper face seems to be the key; for instance, Osipa (2007, p 23) underlines the brow squeeze as being "every expression":

> "To get more specific, squeeze denotes "thought". Absence of squeeze is generally absence of any wheels turning. It's the combination of the brow squeeze, the brow raise, the tilt of the head, the eyes, and the eyelids, working together, that creates an expression."
> (Osipa, 2007, p 23)

In Osipa's opinion, then, the brow squeeze shape is critical to any expression, as it shows the thought process. In the emotional psychology literature, the expression of pure, basic emotions does not necessarily dictate the presence of this element. Nevertheless, from the work of Ekman and fellow emotional psychology researchers, the idea of facial regions definitely feeds into character animation practice, where animators might consider brow, eyes, mouth, and head movement to be distinct areas of varying importance to emotional expression. However, from a review of the animation literature, there does not appear to be consensus amongst animators on the implementation of regional animation. For instance, Clark suggests that "the eyes lead the rest of the face." (Clark, 2002, p 175) while Kalwick indicates that "the mouth is the foundation of every expression." (Kalwick, 2006, p 74). This would suggest that current animation guides to facial animation have a tendency to follow the personal practices and preferences of the authors, rather than being informed by a wider evidence base. This inconsistency in interpretation by animation writers underlines the notion that animation, at its heart, is the output of artistic performance, and variation in interpretation is only to be expected. For instance, Williams (2001) considers the flow of facial movement, but does not offer any advice on which direction expressions should flow in general. In terms of expressional change, he does stress that "it's crude just go from one to the other" (Williams, 2001, p 249), and that movement up or down the face provides a more interesting approach (effectively applying the Overlapping and Secondary Action principles). As shown in Figure 2.6, Williams suggests that Overlapping Action in the face is something animators ought to consider, but he does not present one option as being more effective than the other. There is no prescriptive movement to facial expressions here – simply an idea for animators to experiment with. In other words, it is understood that variation in facial timing is an important aspect of creating believable animations, but thus far no practitioner has attempted to demonstrate the effects and uses of that variation more broadly than indicating a personal preference. However, the following quote highlights one common method which may apply to regional timing: the use of reversal.

> "The most dramatic emotion shifts can be given a higher intensity by shifting the asymmetry in reverse. For example, pretend the character is smiling out of the right side of his mouth and his right eyebrow is down. Now he becomes angry and shifts to a frown on the left side of his mouth and raises his right eyebrow higher than the left. This reversal gives the character's internal emotional shift an extra kick, helping it to read more clearly."
> (Clark, 2002, p 169)

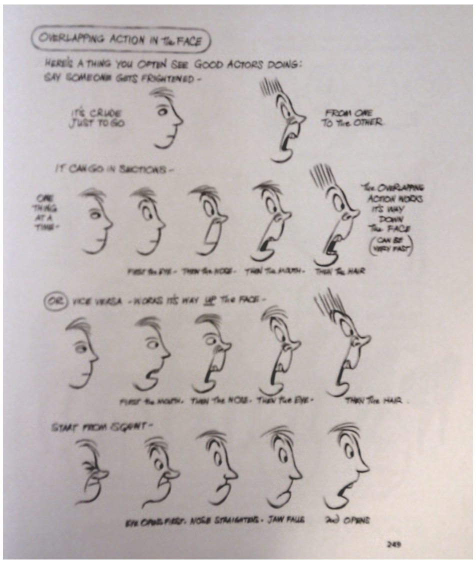


Figure 2.6: William's (2001) suggestion that overlapping action (movement up or down the face) is less crude that simultaneous movement from expression to expression.

Clark underlines how reversing the pose asymmetrically can assist with the Staging of both the first and second emotion. This technique perhaps best demonstrates the importance of context to expressional timing and movement; for instance, a shift between a happy expression and an angry expression may emphasise the lower face (smile) for the first emotion and upper face (frown) for the second emotion. Yet in another emotional context, say happy to disgusted, an appropriate use of reversal may be more difficult to identify (since both these expressions are distinguishable by strong lower face shapes). In considering the practitioner's treatment of facial expression animation, then, it is clear that the reflexive nature of practice-research and consideration of the principles of animation are crucial. At present, no comprehensive account of practitioner experiences while manipulating expression 'choreography' exists, and so any practice-based study of facial expression sequence and timing should aim to fill this gap.

2.3 Synthesising emotional expressions

So far, this chapter has covered related research in emotional psychology, natural facial expressions, and the perspective of animation practice. The aim of Emotional Avatars is to conduct practice-led research into the animation of emotional facial expressions, and, as such, these areas of research and practice underpin the project. Moving forward, research into the computer animation of expressions must now be addressed in order to highlight the niche that the Emotional Avatars research fills, and the potential application of the project outcomes. While psychology research into facial expressions often makes use of computer software to generate synthetic expressions for testing – for instance the work of Calder et al. (1997) – the research conducted by academics in the fields of computer animation and affective computing is arguably of the most importance to the project, particularly so as this work is closely linked to creative and technical developments in the animation of virtual characters for computer games and interactive media.

2.3.1 The spatio-temporal characteristics of expressions

Clearly, computer animation is heavily dependent on knowledge of the spatial and temporal attributes of expressions. It has already been shown earlier in this chapter that facial expressions can be associated with underlying emotional experiences, and that certain expressions may be universally recognised by observers. Some of the features of these expressions were highlighted by Darwin (1872) and Ekman and Friesen (1975), and the exact nature of expression appearance over time has subsequently been explored by researchers in the fields of emotional psychology and computer animation. As regards the temporal attributes of facial behaviours, studies have shown that the movement of facial expressions alone is sufficient for observers to accurately identify emotion (Bassili, 1979). More recent studies have generated similar results. In particular, a series of experiments by Cunningham, Wallraven and colleagues has shown that dynamic expressions are easier to identify than static expressions (Cunningham and Wallraven, 2009a; Wallraven et al., 2008), that accurate display of facial expressions does not necessarily enhance identification rates (Wallraven et al., 2007), and that movement information alone is sufficient for accurately conveying emotional expressions to observers (Cunningham and Wallraven, 2009b).

While observer perception of expressions is clearly enhanced through the introduction of motion, manipulation of the duration of expressions may not have any discernable effects on expression identification. Pollick et al. (2003) demonstrated that manipulation of the overall duration of facial expressions had limited effects on the rating of emotional intensity and expression identification, suggesting that the overall timing of an expression animation may be irrelevant in this respect. On the other hand, Krumhuber, Manstead and Kappas (2007) revealed that the authenticity of an emotional facial expression could be affected by manipulating the duration of the facial movement. Their study indicated that the onset duration of a smile could have a significant impact on observer ratings, with longer smile onsets appearing more dominant, trustworthy, and attractive. The overall duration of an emotional expression could therefore be open to further experimentation, although the work of Ekman (1992) and others would certainly point towards emotions having short durations by definition (as discussed earlier).

Where the temporal dynamics of emotional expression perhaps becomes more interesting is in the sequential development of features. For instance, Messinger et al. (2001) determined that naturalistic smiles tend to emerge in the lower face – with the appearance of the smile itself – before development of the Duchenne smile (or wrinkling around the eyes) later on in the expression. Similar studies of video data have indicated that emotional expressions do unfold as a sequence of more subtle expressions (Bänziger and Scherer, 2007; Keltner, 1995). These findings can be connected to the idea of extended appraisal, as covered in section 2.1.2, and to Scherer's component process model. From this angle, an emotional experience can be thought of as a series of evaluations, which is reflected on the face through subtle changes in expression. However, related research into the effect of sequence manipulation is fairly limited. Wehrle et al. (2000) sought to test theoretical predictions based on Scherer's component process model, by producing and assessing the perceptual validity of animated expressions. Identification rates of these more refined dynamic expressions were lower than, but still comparable to, identification rates for prototypical acted expressions. The authors of this paper underlined the complexity involved in researching the potential dynamics of expressions using the experimental method, highlighting a range of potential variables (for instance, the possibility that an expression may contain more than one apex based on regional intensity). Other work on the effect of expression sequence includes Malatesta, Raouzaiou and Kollias (2006) and Paleari and Lisetti (2006), but overall this area of research remains largely unexplored.

While sequential internal movement within expressions has proven troublesome experimentally, it has been demonstrated that specific facial regions can play a key role in expression recognition (Adolphs, 2002; Calder and Young, 2005). Nusseck et al. (2008) revealed compelling insights into the importance of facial regions, head, and eye movement to expression recognition. Across a range of dynamic expressions, it was found that different areas of the head and face were either sufficient or necessary to expression identification. For instance, it was demonstrated that happiness and surprise were best communicated through movement in the mouth region, whereas the eyes region was sufficient for a thinking expression. Other expressions, including sadness and disgust, required more complex combinations of head and face movements in order to enhance identification. Generally, it was found that the core facial regions of brows, eyes, and mouth were necessary in some respect for expression identification, while movement in the head or eyes alone could occasionally infer the emotion. This research not only demonstrates that manipulation of nuanced regional movement can have an effect on observer perception, but also that complex expression dynamics can be subject to perception experimentation if the variables are clearly identified.

At present, it is clear that broad and regional facial movement can have measurable effects on perception. However, the effect of sequential movement on emotional facial expression perception remains largely untested, and results that have been published are somewhat inconclusive. This is predominantly due to the complexity of manipulating expression sequence for experimental testing. Nevertheless, the importance of temporally configured, nuanced expressions to character animation cannot be understated. In traditional animation, exposition of the thought process is the key to creating believable expression animation (as discussed by Hooks, 2000). Here, the processes which are covered by Scherer (1994) and which were tested by Wehrle et al. (2000) are typically considered by the traditional animator, who will make value judgements when animating expression development on the face. This is clearly a subjective procedure driven by performance rather than empirical evidence, yet the development of sequential movement in traditional animation is fundamental to the production of lifelike animation. Recently, researchers working in the field of character animation and behaviour modelling have sought to develop multimodal sequential expressions for virtual characters (Newiadomski, Hyniewska, and Pelachaud, 2009; Pelachaud, 2009a). Here, the authors acknowledge a lack of empirically-backed guidance on the effects of spatio-temporal dynamics, and instead turn to theoretical models of emotion, such as the work of Scherer. It would therefore appear that, although the effects of expression dynamics may prove difficult to detect experimentally, the desire to implement more complex dynamics in virtual character facial animation is great.

2.3.2 Methods for visualising computer animated emotional expressions

While the traditional approach to facial animation – for both film and games – concerns the artistic application of practical techniques, the computer animation research community is predominantly concerned with a more objective approach to facial expression replication. A summary of the most common methods for visualising synthetic expressions within this domain is essential in order to clearly identify how a method of creative animation production relates to (and differs from) the methods of computer animation research.

One of the common expression visualisation techniques which closely relates to the creative animation approach is the method of mesh interpolation, sometimes referred to as the use of morph targets or blend shapes in both computer animation research and 3D arts packages (in this case, Autodesk 3DS Max and Maya respectively). This method is dependent on the creation of a series of target meshes, where each mesh represents a different facial expression or subtle muscular movement. These meshes are used to define the dynamic appearance of the primary facial mesh, and mesh targets can be both incrementally applied as well as combined with other meshes to create distinct facial expressions. Unlike the creative application of mesh targets in animation, research into expression synthesis typically makes use of mathematically driven animation to control mesh interpolation (Arai, Kurihara and Anjyo, 1996; Deng et al., 2006; Pighin et al., 1998). In recent years, methods which employ mesh interpolation have been used in a range of computer animation studies (e.g. Albrecht et al., 2005; Britton et al., 2006). Mesh deformation methods function in a similar manner, using a variety of techniques to warp the mesh. Free-form deformations (FFD) (Sederberg and Parry, 1986) make use of a lattice with control points weighted to the vertices of the underlying mesh, so that facial meshes can be animated through manipulation of control point positions over time (Kalra et al., 1992). B-splines may also be used in mesh deformation (Catmull and Clark, 1978), often mimicking the movement of facial muscles (Wang and Forsey, 1994). An alternative approach to mesh interpolation or deformation is the parameterisation method, which is used to define the position of vertices on the mesh surface (DeCarlo and Metaxas, 2000; Parke, 1989; Pyun et al., 2006; Waters, 1987). Although not as flexible as the blend shapes method, building animated expressions in real time through the movement of vertices is not as expensive computationally, allowing for the real time control and animation of facial expressions (for example, Perlin and Goldberg, 1996). The MPEG-4 standard accommodates expression manipulation using facial animation parameters (FAPs) (Escher, Pandzic and Thalman, 1998). This method of facial animation synthesis has been of interest to the computer animation research community over the last decade, particularly because of the capacity to deploy facial animations over the Internet (Garchery and Thalmann, 2001; Pandzic, 2002). Physics-based methods for synthesising expressions attempt to simulate muscle movement in order to move mesh vertices in a realistic fashion (Kahler, Haber and Seidel, 2001; Zhang, Parkash and Sung, 2001). By simulating muscle movement, the physics-based approach is effective for replicating authentic movements, for instance the movement of the lips region during speech (Sifakis et al., 2006).

Realistic lip-movement has posed a significant problem to both computer animation researchers (Parent, King and Fujimura, 2002) and practitioners (Osipa, 2007) alike. To tackle the issue, a range of methods that incorporate both visemes and phonemes have been used in facial animation synthesis. Viseme animation typically makes use of viseme shapes which are procedurally animated and smoothed to create realistic lip synthesis, often driven by speech (Caldognetto, Perlin and Zmarich, 2002; King and Parent, 2005; Lewis, 1991). While speech can be interpreted by the computer to synthesise facial animation, motion or performance capture (as discussed earlier) is currently the principal method used to generate synthetic expressions on 3D meshes. There are a variety of approaches to motion capture. Magnenat-Thalmann, Cazedevals, and Thalmann (1993) demonstrate the use of image processing to recognize recorded expressions.

The traditional approach, however, has been to use markers in order to accurately track the movement of expressions (Caldognetto et al., 1989; Patterson, Litwinowicz and Greene, 1991). Full 3D motion capture using points is an established method for capturing performances (Choe, Lee and Ko, 2001; Joshi et al., 2003; Sifakis, Neverov and Fedkiw, 2005), particularly so for animated films. Increasingly, the move towards marker-free performance capture has made the process of recording and acquiring motion data more accessible, with the Image Metrics (2010) service (discussed in Chapter 1) representing an key example of the technology currently available. In all cases, the goal is to use actual physical movement from captured acted performances to drive facial animation.

An extensive overview of scientific methods for synthesising computer facial expressions is covered in Parke and Waters (2008). On the whole, there are many techniques and methods which can be used to synthesise facial expressions, both in terms of the technology behind the computer visualisation as well as the algorithms or data used to drive movements. Some research has acknowledged the role of the human animator and the importance of artistic influence on performance production (e.g. Chang and Jenkins, 2006). Nevertheless, the vast majority of the work concerns an objective, positivist approach to animation research, with little or no input from creative practitioners. In character animation production, artistically-minded animators employ the tools and technologies developed by computer animation researchers on a daily basis. Techniques such as mesh morphing, free form deformation, and motion capture are all useful to the animation practitioner. And yet, while the methods of facial animation synthesis form part of the animator's toolset, the production of believable expression animation from the animator's perspective lies not with technology but through the application of creative principles. In essence, the current research into the animation of emotional facial expressions does not make use of formalised animation practice as a research method in itself. By adopting a creative approach to facial animation research, where the principles of animation described by Thomas and Johnston (1981) underpin the artistic development process, the Emotional Avatars project addresses a niche which has largely been overlooked in the computer animation research community.

2.3.3 Embodied agents

Embodied agents, often described as embodied conversational agents (ECA), are computationally driven virtual characters which are designed to mimic human behaviours (Cassell et al., 2000). Typically, ECAs have been developed which can express basic emotion, for instance Becker, Kopp and Wachsmuth (2004) and Egges, Kshirsagar and Magnenat-Thalmann (2002). For the most part, ECA research has been based on theoretical models of emotion and cognition, including the work of Ekman, Scherer and others discussed earlier in this chapter. A key aspect of ECA research has been to achieve believable, automated facial animation which can accompany speech (e.g. DeCarlo et al., 2004). Additionally, methods of synthesising authentic head motion driven by speech have been developed (Busso et al., 2005).

Recent research into the development and evaluation of expressive ECAs has shown that believable, dynamic virtual characters can be produced. Pelachaud (2009b) describes how a model of behaviour expressivity – founded on previous research by Wallbott (1985, 1998) and Gallaher (1992) – could be used to generate embodied agents which display expressive gestures. In terms of facial expression, work on ECAs has demonstrated that intricate emotional states can be modelled and expressed for virtual characters. One notable example of this is the generation of masked facial expressions (the deliberate disguising of felt emotions, covered earlier in the chapter) which have been produced by Belvacqua et al. (2007). The scope for developing individuality in an expressive ECA has been researched (Mancini and Pelachaud, 2008). Furthermore, researchers have sought to model more complex affective states for ECAs, such as mood and personality (Arya et al., 2006; Egges, Kshirsagar and Magnenat-Thalmann, 2004; McRorie et al., 2009). Current embodied agents may, for instance, be capable of expressing affective states which are modulated by both personality traits and experienced emotions (Arellano, Varona and Perales, 2008). As well as accounting for a range of affective states, the potential for human-computer interaction using ECAs has underpinned research into the reproduction of virtual character expressions which convey empathy (Niewiadomski, Ochs, and Pelachaud, 2008). Increasingly, then, ECA research is concerned with modelling and visualising detailed, multimodal virtual characters (de Melo and Paiva, 2006).

However, as has been demonstrated throughout this section of the chapter, the majority of research into the animation of expressive virtual characters has been based on studies of natural behaviour. While some consideration has been given to how artistic principles can be adopted to achieve particular effects (Pelachaud, 2009b), to date there has not been a rigorous investigation of emotional expression from the perspective of creative animation practice. Indeed, Pelachaud (2009b) indicates that research of this nature “would deserve a study on its own”. As stated previously, the lack of focussed arts-based research into the computer animation of facial expressions represents a considerable gap in knowledge, and the proposed Emotional Avatars research would be well suited to address this niche. When the work on ECAs is also considered, it is evident that practice-based research into expression animation would prove useful more broadly, informing the animation of virtual characters that already have advanced psychological models underpinning their behaviours. This links back to the earlier discussion in Chapter 1 on the animation of virtual characters in games and other forms of interactive media. Traditionally, games characters have been animated using the creative principles set out by Thomas and Johnston (1981). Conversely, the work on embodied agents has primarily sought to advance the technology behind procedurally animated characters based on psychological models; in essence, replicating natural behaviour. The Emotional Avatars research should therefore look to introduce the idea of arts-led research in emotional expression animation, with explicit connections to the embodied agent and affective computing research communities. This is essential in order to ensure that the creative principles of animation are embedded in future work on virtual characters.

2.4 Chapter summary

Over the course of this chapter, a broad range of associated literature has been examined and discussed. Starting with the nature of emotion and expressions, theories of emotional experience and cognition were presented, focussing in particular on the work of Plutchik, Ekman, and Scherer. The underlying emotional processes – encompassing the evolutionary role of emotions, physiological reactions, and individual appraisal of events and feelings – are fundamental to effective character animation. Discussion of emotion in relation to other affective states, cultural and social factors, and expression universality was not only a necessary prerequisite to focussed research into expression animation, but would also later inform the establishment of a critical procedure for animation production and analysis. The details of this procedure are laid out in the next chapter.

In order to flesh out the concept of emotional expression research through studio practice, related work in animation theory and production was presented. Here, the work of Thomas and Johnston proved to be essential reading, and the guiding principles of animation were listed and examined in the context of emotional facial expressions. As with the related work in emotional psychology, these principles would greatly inform methodology design for the Emotional Avatars research. Discussion of performance capture and the threat of the uncanny valley in hyper-real animation clearly demonstrated the continuing importance of the principles of animation, which were established more than 75 years ago. The work of contemporary facial animation practitioners was reviewed in order to highlight the current understanding of emotional expression dynamics from the artistic perspective.

Linking back to the initial project aim – the ambition to spatially and temporally choreograph emotional facial expressions – the related literature on facial expression movement and computer animation was reviewed. Here, it was shown that relatively little was known about internal dynamics and development of emotional expressions. It was clear that expression duration could be linked to perceived authenticity and that facial regions play important roles in expression interpretation. As regards sequential movement, only a few studies appeared to address this area of expression dynamics, and none had demonstrated that a particular sequence of facial movement dramatically enhanced expression perception. The related work in computer animation was overwhelmingly based upon purely naturalistic or objective means of capturing and synthesising real expressions as accurately as possible. Many of the technical advances in the field of computer animation, however, are utilised by practising creative animators, enabling them to produce more flexible and adaptable character setups. The computer facial animation literature therefore provided further rationale for research into the creative animation of expressions, and also informed the development of animation production methodologies. Finally, expanding on the discussion of virtual character performances in Chapter 1, an overview of the related literature in the field of embodied agents confirmed not only that more work is needed in order to better understand the movement of believable expressions in various contexts, but also that there is a demand for adaptable computer avatars that are high on both agency and character performance.

From this review, it is evident that the research questions posed in Chapter 1 are rational, and that the proposed approach of using creative, experimental, and qualitative methods in order to examine expression dynamics is novel. Over the last century, researchers in the field of facial expression and perception have developed tried and tested experimental methods, providing a platform for animated expression assessment and yielding a wealth of findings with which to compare experimental results. However, it is clear that dynamic expressions are immensely complex, and presently it would seem that a purely experimental approach to investigating the concept of choreographing expressions would prove cumbersome. As practice-based visual arts inquiry has found a foothold in formal research in recent years, the proposed mixed-methods, multidisciplinary approach to researching emotional expression dynamics artistically, scientifically, and qualitatively is well timed. How such a mixed-methods approach can be structured is the subject of the next chapter.

Chapter 3
Research framework and methods:
practising and observing animation

> "Within the field of science, there is a growing recognition that restricting enquiry to those things that can be exactly measured would mean denying many of the benefits of alternate modes of enquiry."
> (Barrett, 2009, p 4)

The nature of Emotional Avatars – as a project that is rooted in both animation practice and scientific inquiry – demands an interdisciplinary, mixed-methods approach. While the methods of various research paradigms can be adopted and executed in isolation in order to investigate the appearance and perception of dynamic expressions, one epistemological perspective alone is insufficient for addressing the project aim as set out in Chapter 1. Emotional facial expressions appear in nature, and their movement and appearance can be measured using established scientific methods. But as discussed in the previous chapter, character animation is also about artistic performance, which is ultimately the outcome of creative (and, arguably, highly subjective) practice. As such, the purpose of this chapter is to outline and justify the selection of a mixed performative-quantitative-qualitative research framework designed for the investigation of facial animation production and perception. Each of these three research paradigms are discussed in more detail in sections 3.2, 3.3, and 3.4, with particular emphasis on the emerging performative (or practice-based) research paradigm. In the discussion of these research paradigms, the rationale of each approach in relation to the project is explained. This discussion is substantiated with demonstration of how the methods of each approach can address particular research questions. The overall research framework is brought together in section 3.5, which covers the theoretical and structural formation of the mixed-methods design. Finally, an overview of the practice-led methodology is presented in sections 3.6 (detailing the performative methods and analytical procedure). Firstly, though, the project goals are restated and examined in order to clarify how each paradigm for research corresponds with a specific research question.

3.1 Emotional avatars goals

Returning momentarily to the project aim, it is clear that the stated range of research approaches must be embraced in order to address the goals of the Emotional Avatars research. The project aim is as follows:

> ‘To conduct practice-based studies of animation in order to explore the concept of emotional expression choreography, and develop an artistic understanding of dynamic expression animation that can be assessed and contextualised through studies of human perception and interpretation.’

As discussed in Chapter 1, the above project aim and the resulting research questions can only be addressed using a mixed-methods approach. There are three primary research questions that emerge from this project aim:

1. Can creative animation practice reveal a means of choreographing perceptually valid emotional facial expressions?
2. Will emotional expression choreography modulate observer perception of animated expressions?
3. Will animators and audiences show consensus in their interpretation of choreographed emotional expression animations?

These three primary research questions correspond with the paradigms of performative, quantitative, and qualitative research respectively. Clearly, Question 1 implies the use of methods of animation production as a form of creative exploration – essentially, research which is rooted in studio practice. Question 2 can be related to more standardized forms of face perception research, utilizing adapted quantitative methods in order to measure observer responses to facial stimuli. Finally, Question 3 is concerned with the deeper, interpretive meaning of animated expressions, and as such can be addressed by adopting qualitative research methods. These three research paradigms broadly relate to three types of encounter with facial animation; the highly subjective perspective of the researcher, the objective perspective of a general audience under controlled conditions, and the intersubjective interpretation of practitioners and audiences in more natural settings. The practitioner-researcher encounters choreographed emotional expression animation as an experienced artist and animator, employing expertise in character animation practices and tools in order to iteratively create and refine facial expression performances. The practitioner-researcher's experiences are deeply personal, reflexive, highly subjective, and his research findings may not necessarily be replicated in further practice-based research. Conversely, the general observing audience experiences only the output of the researcher's creative practice – the finished facial animations. These experiences occur under more tightly controlled conditions, allowing for precise measurement of the observer's perception of choreographed emotional expression animation. Lying between these two disparate encounters with animation are the more intersubjective, meaningful experiences smaller samples of participants have with choreographed emotional expressions, both as animators and as audiences. Like the practitioner-researcher, fellow animators encounter facial animation from the perspective of artistic practice and, by that logic, each individual's experience is potentially unique. However, the experiences these participants have with choreographed emotional expression animation can be treated as a phenomenon experienced by a group of practitioners. As such, the epistemological stance here is that knowledge can be acquired by studying the *collective* perspective of individuals. While differences of opinion can exist, so too can a degree of consensus, with common themes emerging from participant's intersubjective experiences with animation. Similarly, the intersubjective and meaningful experiences audiences have with choreographed emotional expressions can be investigated in much the same way, allowing audiences to articulate their individual and collective interpretations of expression animations in more detail.

By investigating facial animation production and perception from these three angles, the concept of emotional expression choreography can be explored artistically, empirically, and through the use of interpretive methods. In order to achieve the aim of the Emotional Avatars project, a research methodology was developed which would cater for this broad view of dynamic expression animation, which in turn would lead to firmer conclusions regarding the potential role of emotional expression choreography. The following three sections will detail the paradigms of performative, quantitative and qualitative research in relation to the Emotional Avatars project.

3.2 Research through creative animation practice

> "Since creative arts research is often motivated by emotional, personal and subjective concerns, it operates not only on the basis of explicit and exact knowledge, but also on that of tacit knowledge. An innovative dimension of this subjective approach to research lies in its capacity to bring into view, particularities that reflect new social and other realities either marginalised or not yet recognised in established social practices and discourses."
> (Barrett, 2009, p 4)

While the production of natural emotional expressions can be explored scientifically, the artistic production of emotional expressions is a separate matter. In painting, sculpture, graphic art, motion pictures, and in animation, the artist's depiction of emotional expression is one which is often rooted in natural truth, but which also draws upon a degree of tacit artistic knowledge. For example, the principles of animation (Thomas and Johnston, 1981) discussed in Chapter 2 imply the application of unnatural occurrences, such as Anticipation and Exaggeration. Animators can begin working on character expression by observing natural movement but, through the application of the animation principles, they can choose to skew and distort the natural movement to create an artistic dramatization – rather than an accurate replication – of life. And yet the driving force behind the principles of animation is that creative intervention in this way can result in animated characters which audiences find *more* believable than characters which have accurate, naturally occurring movements.

The researcher who aims for objectivity in the collection, recording, or generation of emotional expression videos does so because it ensures scientific rigour and maximises the chances of replication. However, the empirical researcher is not well placed to examine the reasoning and practice-based interpretations of the character animator. In the human and social sciences, qualitative studies can be designed to collect and compare the subjective interpretations of animators, and this approach has more scope than quantitative methodologies when it comes to understanding intersubjective artistic practice and interpretation. However, neither approach is truly suited to practice-based arts research. In fact, the insistence that artists should conduct research using scientific frameworks (either quantitative or qualitative) can be detrimental to the development of truly artistic research methodologies. As Sullivan succinctly puts it, the "source of dilemmas about definitions and methods facing practice-based researchers is relatively simple: *artists are not social scientists*" (Sullivan, 2008). Chief among the reasons why artists should not be expected to conduct research as social scientists is the issue of interpretation:

> "…Arts and Humanities do not share the same world-view as Science. In the former disciplines, the perceiving subject's personal experiences have a greater importance than in the latter. Indeed, we might say that variation in interpretation is one of the cornerstones of Arts and Humanities."
> (Biggs, 2008, paragraph 3)

While scientific approaches to facial animation research is certainly appropriate for later studies that relate to the measurement of perception and the intersubjective interpretation of character animators and audiences, human science research methods are not ideal for research in visual arts practice. The notion that arts based researchers should conform to established qualitative approaches simply because they are more appropriate than quantitative methods is troublesome. From the artistic perspective, practice-based research is motivated by the generation of meaning, rather than the scientific investigation of objective or intersubjective facts that drive quantitative and qualitative research respectively:

> "Art *practice* is, in and of itself, a specific and special form of *research*. In the arts, the very idea of a qualitative-quantitative divide becomes irrelevant because by its distinct nature arts research calls for a different set of categories where the arts do not *search* for stuff or facts, but they *generate* it."
> (Baldacchino, 2009, p 4)

When it comes to the investigation of emotional expression animation, then, the artistic epistemological perspective is adopted in order to explore the potential of emotional expression choreography, rather than to prove or disprove the effects of choreographed expressions. As Baldacchino states, the purpose of art practice (as a form of research) is to "generate" knowledge.

In the context of the Emotional Avatars project, practice-based arts research is therefore about the exploration of facial animation dynamics through creative practice, with a view to informing and underpinning subsequent scientific studies. Because this form of research is subjective, reflective, and ultimately takes place under uncontrolled studio conditions, it is crucial that the role of the researcher and the validity of the artistic output are explained in some detail.

3.2.1 The practitioner-researcher

An arts practice-based approach to animation research should allow the researcher to explore ideas and concepts through practice, generating new knowledge based upon artistic encounters and reflections. Existing knowledge about animation techniques, including the principles of animation, is essentially knowledge that resulted from research through creative practice, not strict scientific study (Thomas and Johnston, 1981). In arts-based research – as opposed to empirical research, but similar to some forms of qualitative research – the researcher must become completely immersed in the research activity. However, the artistic researcher becomes much more involved in the research activity than a typical qualitative researcher. The artistic researcher *is* the research participant and the principal generator of data, whereas the qualitative researcher is effectively an observer whose level of immersion and interaction with research participants is dictated by the selected research method. The role of the creative arts researcher is best described as a *practitioner-researcher*. As Gray and Malins describe, this approach is quite different to scientific research:

> "In the role of the 'practitioner-researcher', subjectivity, involvement, reflexivity is acknowledged; the interaction of the researcher with the research material is recognized. Knowledge is negotiated – inter-subjective, context bound, and is a result of personal construction. Research material may not necessarily be replicated, but can be made accessible, communicated and understood."
> (Gray and Malins, 2004, p 21)

The nature of interpretation is of the utmost importance when considering how practice-based research in the creative arts is conducted. The subjectivity of the practitioner-researcher's interpretation is clearly acknowledged in the arts research paradigm, as indicated by Gray and Malins above. Furthermore, it is expected that this interpretation should be predominantly based on the researcher's own creative practice. This type of researcher is now well established as a valid and justifiable role in creative arts research (Gray and Malins, 2004; Gray, 2006, 2007; Gray and Burnett, 2008; Elkins, 2009a; Sullivan, 2009). However, part of the above statement by Gray and Malins suggests that qualitative research design does influence the artistic research methodology – the point that "knowledge is negotiated – inter-subjective, context bound, and is a result of personal construction" (Gray and Malins, 2004, p 21). This concept can be aligned with constructivist epistemology, in that it refers to personal and shared experience as a gateway to knowledge. And it is indeed true that qualitative methods can compliment artistic research – the multi-paradigm rationale of the Emotional Avatars project acknowledges the fact (qualitative research for the Emotional

Avatars project is discussed in section 3.4). Nevertheless, as discussed previously, qualitative methodologies cannot be made to accommodate artistic research simply because there is a greater degree of overlap than there is with quantitative methodologies.

Gray and Malins (2004) distinguish the practitioner-researcher approach as an emerging artistic paradigm, with ontological and epistemological considerations that are distinct from more established perspectives. Haseman (2007) also recognizes this distinction, and calls for arts practice-research to be acknowledged as a third research paradigm, alongside the quantitative and qualitative approaches. He describes the third paradigm as "performative research" - the performing of action in order to carry out creative practice-based research. The underlying principle here is that "the new can be seen to emerge in the involvement with materials, methods, tools and ideas of practice." (Bolt, 2006). This emergence of knowledge is crucial to the performative paradigm. As Slager comments:

> "Artistic research can never be characterized by a well-defined, rigid methodology. Rather, its form of research could be described as methodical: it entails a strong belief in a methodologically articulate result founded by operational strategies that cannot be legitimized beforehand."
> (Slager, 2009, p 55)

Elkins concurs with this assertion, suggesting that the most promising definition of knowledge generated through artistic practice is that it is a "persuasive articulation of… unpredictable results" (Elkins, 2009b, p 122). Essentially, the performative paradigm allows the artist to adopt the "dual roles of the *researcher* and the *researched*" (Sullivan, 2008) in that the artist conducts research through creative practice and then forms a critical interpretation of their experience using reflexive processes. In contrast with the notion of the qualitative researcher suggested by Moustakas (1994) – that the researcher can form his or her own interpretation of a phenomenon, then proceed to conduct research by gathering the intersubjective interpretations of research participants – the performative researcher conducts research through creative practice, and forms interpretations that are the basis of new knowledge by reflecting on their own experiences.

3.2.2 The reflective practitioner

> "As we think and act, questions arise that cannot be answered in the present. The space afforded by recording, supervision and conversation with our peers allows us to approach these. Reflection requires space in the present and the promise of space in the future." (Smith, 1994, p. 150)

With a distinction between qualitative and performative paradigms established, further distinction between the two performative phases of practice and reflection is crucial. As highlighted by Smith above, effective reflection is dependent on the separation of action and reflection, and in particular on the allocation of time to reflect after action. In other words, the practitioner cannot reflect upon and critique the output of practice *during* practice. The creative phase will undoubtedly generate thoughts and questions, but these must be explored through the artwork (or recorded in accompanying sketchbooks and journals) during practice, and then reviewed in the subsequent phase of structured reflection. The concept that knowledge is acquired or generated through practice (or action) is not unique to the creative arts. The following statement by Donald Schön perhaps best summarizes the idea that knowledge can emerge from and be demonstrated by our actions:

> "We often cannot say what it is we know. When we try to describe it we find ourselves at a loss, or we produce descriptions that are obviously inappropriate. Our knowing is ordinarily tacit, implicit in our patterns of action and in our feel for the stuff with which we are dealing. It seems right to say that our knowing is in our doing."
> (Schön, 1983, p 49)

This statement – and the work of Schön in general, not to mention the work of subsequent champions of reflective practice (Kolb, 1984; Johns, 1995; Taylor, 2006) – hits a chord with many creative arts researchers. It has long been understood that artistic practice reveals new ideas, concepts, questions, or theories; in essence, that we "come to know the world theoretically only after we have come to understand it through handling" (Bolt, 2009, p 30). Indeed, reflective practice and theories of educational experience are often referenced in papers about artistic practice. One such example is research into the learning experience of textile designers undertaken Maggi Toner-Edgar (2008), who comments that "reflection can help us as practitioners and educators to define our purpose and gain deeper understanding" (Toner-Edgar and Philips, 2004). Structured methods of reflection (which are typically targeted at educational or nursing practitioners) also influence the work of creative practice-based researchers. For example, in his research into theatre direction, Fenton (2007) took influence from nursing researcher Johns' (2002) Model of Structured Reflection (MSR).

Reflective research can therefore be used as a key component of research projects which have a focus on generating knowledge through practice. In using reflection as a method of research, however, it is essential to consider the role of the reflective practitioner, and the nature of their reflections. As Taylor points out:

> "…the epistemological assumptions of reflection are that knowledge is partially objective or subjective, context-dependant and relative, making no claim as absolute or certain 'truth', but rather as socially constructed representations of 'truth' that provide tentative answers to issues and problems and to 'useful for now' descriptions of meaning and experience."
> (Taylor, 2006, p 168)

It should therefore be made very clear from the outset that, as a means of analysing practice, methods of reflection on practice offer only the subjective and contextually dependant interpretations of the practitioner-researcher conducting the study.

3.2.3 Performative research for facial animation

The performative research paradigm for creative arts practice is the logical approach for an investigation into the production of animated performance, where the experiences of the practitioner (reflecting in- and on-practice) are paramount. Specifically regarding facial expression animation and the concept of emotional expression choreography, it enables a formal research methodology for systematically and rigorously exploring the artistic reasoning behind the temporal unfolding of animated expressions.

The first stage of research of the Emotional Avatars methodology is therefore based on the concept of performative research. Table 3.1 summarizes the characteristics of the performative paradigm adopted for conducting artistic research into the production of animated facial expressions. The methods for conducting performative research for the Emotional Avatars research project are discussed in section 3.6, while the relationship between the performative research and other methods is outlined in section 3.5.

Table 3.1: Performative paradigm characteristics for the Emotional Avatars research.

Paradigm	Performative
Ontology	Artistic - knowledge can be acquired through engagement with and reflection on artistic practice
Epistemology	Subjective / practitioner-researcher
Selected Methodology	Practice-based research
Research Material	Research material is generated, manipulated, and interpreted by the practitioner-researcher
Validity	Exposition of process and output, reflections and reasoning made available
Reliability	Practitioner-researcher acknowledges and declares their subjectivity and artistic capability

3.3 Observer perception of animated expressions

The performative research paradigm is appropriate for framing the practice-led research approach of the Emotional Avatars project. However, this approach does not in itself cater for traditional scientific experimentation, as the methods, tools, and modes of analysis are necessarily creative, reflective, and subjective. As Candy et al. (2002) declare, in creative arts research "controlled laboratory experiments are not achievable without sacrificing the context that gives them meaning". The dismissal of positivist experimental approaches to research by practice-based researchers is somewhat understandable, as the act of quantifying data derived from practice-research effectively strips all value from the findings. However, Candy et al. also submit that "when studies of creativity are carried out, real-world context is an important consideration". In this sense – and with the project research questions in mind – an experimental approach to measuring and analysing observer perception of the output of arts-practice (in this case, facial animation) is apt.

3.3.1 The positivist empirical approach

Adoption of the scientific method for carrying out objective research into the human perception of expressions is wholly appropriate for addressing the second research question, which implied the need to generalise findings related to the effect of choreographed emotional expressions to a hypothetical 'universal' audience. Certainly, the findings of the performative research, while useful from an artistic point of view, could not be used as the basis for generalisation of the impact choreographed expression animation may have on an audience. As such, the positivist empirical approach to assessment of the *outcome* of performative research – animations intentionally produced with artistic manipulation of a range of variables – could be used to determine whether emotional expression choreography has a measurable effect on audiences.

3.3.2 Quantitative research for emotion and facial animation

Quantification of both emotion and emotional expression is well established in psychological research, and so there is a wealth of literature which can be consulted in order to inform the development of quantitative methods of inquiry into facial animation. As regards emotional experience, a common trend has been to rely on self report of emotion – an idea dependent on the research participant's capacity to consciously evaluate and rate their current or a past emotional state (Barrett, 2006). Using self report, emotion can therefore be quantified using rating scales to measure, for instance, how happy, sad or angry a participant feels. An alternative approach to emotion quantification relates to the physiology of the participant, where researchers measure physiological responses, such as heart rate or skin conductivity (Ekman, Levenson and Friesen, 1983). In the context of the Emotional Avatars research, the most appropriate means of quantifying emotion clearly lies with the assessment of facial expression. One approach to measuring facial expression is to objectively record subtle but observable changes in expression. This approach can be described as the component approach (Ekman, Friesen and Ellsworth, 1982). FACS is a commonly used technique for quantifying observable facial expressions. Using FACS, researchers can record the activation of individual facial muscles and muscle combinations during a recorded facial expression. FACS has been applied as a means of quantifying expressions in combination with other methods of assessing emotion, for instance participant self report (Ekman, Friesen and Ancoli, 1980). Researchers can train to become officially recognised FACS coders, and, typically, manual FACS assessment stipulates that two FACS trained coders are used to assess the activation of FACS action units. In more recent years, automated techniques of action unit assessment based on FACS have been developed. For instance, Bartlett et al. (1999) reported the success of a computer based method of analysing facial movement which was revealed to perform as well as expert coders. Over the last decade, there has been a great deal of research into the development and performance of automated techniques for detecting and measuring facial expression (e.g. Kapoor, Qi and Picard, 2003; Lien et al., 2000; Tian, Kanade and Cohn, 2005). However, the Emotional Avatars research is principally concerned with the perception of expressions by a general audience, not precise measurement of physical movement using either manual or automated coding techniques. In this context, the most appropriate means of quantifying facial expression animation is to measure observer perception using ratings scales. This judgement approach to expression measurement stems from the notion of expression universality, discussed in relation to evolutionary theories of emotion in Chapter 2. As humans have been shown to have the ability to discern between emotional expressions, a valid approach to animated expression quantification is therefore to adopt methods which incorporate participant judgement. The judgement approach to expression measurement is well established in empirical studies of emotion (e.g. Ekman, 1972; Ekman et al., 1987; Izard, 1971; Rosenberg and Ekman, 1995; Thayer and Johnsen, 2000; Wagner, 1997). Table 3.2 summarises the characteristics of a quantitative paradigm for facial animation research. In order to address the second research question outlined in section 3.1 – the question of whether choreographed expression animations would modulate observer perception of expressions – the judgement approach to expression measurement is clearly the most appropriate strategy. In this case, the existing literature on studies of participant perception and judgement of both static and dynamic emotional expressions provides valuable insight which can inform experiment design and data analysis. As Table 3.2 shows, this positivist component of the overall Emotional Avatars research is intended to provide an objective view on the effect of emotional expression choreography through the empirical assessment of participant perception of visual stimuli.

Table 3.2: Quantitative paradigm characteristics for the Emotional Avatars research.

Paradigm	Quantitative
Ontology	Realist
Epistemology	Positivist empirical
Selected Methodology	Experimental
Research Material	Visual stimuli
Validity	Experiment design following established procedures, care taken to design and take measurements, experiments conducted under controlled conditions, possible alternate explanations accounted for
Reliability	Statistical analysis, compared with predictions

3.4 The intersubjective experience of animation

> "The richness and complexity of facial behaviour cannot be captured by a still photograph, nor can the information that facial activity contains be assayed by asking an observer to choose one from a short list of emotions, or to use a rating scale"
> (Ekman, 2005, p 624)

In the previous sections it was demonstrated how performative and quantitative research paradigms could align with the project goals; specifically, the creative exploration and empirical assessment of choreographed emotional expression animation. However, it was also identified in the project aim that a degree of intersubjective consensus may exist regarding practitioner and audience judgement of choreographed expression animations, and that qualitative investigation of participant interpretations could provide more detailed clues regarding the effect of EEC. Creswell (2006) compiles a comprehensive guide to qualitative research, listing five traditions; narrative, ethnography, grounded theory, case study research, and phenomenology. In order to clarify the tradition which aligns most closely with the proposed qualitative studies of facial animation, it is important that the appropriate epistemological perspective is identified. As this aspect of the research project is concerned with how people experience emotional expression choreography, it is clear that the interpretivist theoretical perspective ought to be considered as a means of framing and conducting qualitative research into animation production and perception. With an interpretive epistemology selected, and with the knowledge that the purpose of the research is to reveal interpretation of experience, it is apt that the fifth of Creswell's (2006) traditions – phenomenology – is adopted as the qualitative methodology for the proposed research.

3.4.1 The interpretive phenomenological approach

In his discussion on interpretive epistemology, Schwandt (2003) discusses three stances – phenomenological sociology, empathic identification, and language games – that share common features in line with interpretivism. He argues that interpretivist epistemologies "view human action as meaningful" and that "they share the neo-Kantian desire to emphasize the contribution of human subjectivity… to knowledge without thereby sacrificing the objectivity of knowledge." (Schwandt, 2003, p 193). In essence, the interpretive approach to research seeks to collate accounts of subjective experience in order to focus in on meaning – ideal for incorporating the views of animators and audiences into the overall research framework. In addition, this statement by Schwandt also reiterates the clear distinction between performative and qualitative paradigms; the notion that, while individual participant experiences may be subjective, research findings must ultimately submit to as objective an interpretation of the data as possible. However, while objectivity appears to be a goal to aim for even from the interpretive perspective, qualitative research methods clearly recognize not only the intersubjectivity of human interpretation, but also the subjective interpretation of the researcher. In transcendental phenomenology, for instance, Moustakas states that:

> "At all points in an investigation intersubjective reality is part of the process, yet every perception begins with my own sense of what an issue or object or experience is and means."
> (Moustakas, 1994, p 59)

In this sense, the ontological and epistemological perspectives adopted in some forms of qualitative research do appear to fit with artistic practice-based research, at least to an extent. The difference essentially lies with the level of researcher involvement and, crucially, how to deal with researcher subjectivity. Moustakas (1994) indicates that the phenomenological researcher should declare their position in relation to, and their subjective interpretation of, particular phenomena. This is important in order to understand how the researcher has interpreted participant data. The practice-based researcher will also have their own view on the phenomena under investigation, and this should be declared. However, despite the view that practice-based knowledge is "inter-subjective, context bound, and is a result of personal construction" (Gray and Malins, 2004, p 21), it is clear that the subjective interpretation of the creative arts practitioner – which is manipulated through structured practice – is in fact tantamount to new knowledge in itself. For the creative practitioner-researcher, knowledge stems from the highly subjective process of individual practice and reflection, which can be validated using a number of approaches, including (but not limited to) intersubjective knowledge negotiation. In order to conduct interpretive qualitative research into facial animation production and perception, the subjective experience and involvement of the researcher is acknowledged, but the findings and conclusions must be firmly based on sound evidence and qualitative-scientific rigour.

So, while Moustakas underlines the importance of the researcher's subjective interpretation, the qualitative approach to understanding phenomena such as dynamic facial expressions would ultimately concern the researcher's interpretation of intersubjective experiential data, in relation to both artistic consensus (for production) and audience observation (for perception). This is clearly an important research avenue for dynamic facial expression investigation. In particular, a qualitative approach to facial animation production can be seen as an extension of the highly subjective process of research through creative performance, where the practitioner-researcher encounters, interacts with, and produces animated expressions. In discussing transcendental phenomenology, Husserl (1970) argues that the meaning of experiences – acquired through a process of epoché (setting aside presuppositions and prejudgements) and phenomenological reduction (textural descriptions of experience) – can be researched based on self evidence and personal encounters with phenomena. In terms of facial animation production, this can be likened to artistic methods of research, in that the experience of producing facial animation is highly subjective. As Husserl states, when acting as a transcendental phenomenologist, the researcher is "exclusively within transcendental self-consciousness" and there is "no objectivity as such at all", except as the researcher's encounters with objectivity as subjective phenomena (p 258). In essence, the researcher uses the subjective experience of phenomena (in this case the production of choreographed facial animation) as self-evidence. For rigorous qualitative research, this idea should be taken further, as Moustakas comments:

> "Following our own self-evidence of what appears to us, we check with others regarding what they perceive, feel, and think. In the process of this kind of careful checking we may revisit the phenomenon and discover something new that alters our knowledge of the thing." (Moustakas, 1994, p 95)

Performative methods for animation can therefore be seen as personal and artistically aware encounters with specific, creative phenomena. The process of creative animation production is, to the practitioner-researcher, a self-contained research method, where the output of research is the resulting animations and the subjective observations of the practitioner. This research can be expanded using a qualitative interpretive approach – such as phenomenology, which is of particular relevance to research into the experience of animation production – by embracing intersubjective evidence. Effectively, the performative research emphasises the interpretation of the practitioner-researcher after personal, subjective practice; the qualitative interpretivist approach emphasises the researcher's declared subjective interpretation of intersubjective data (the experiences of others). With this in mind, interpretivist phenomenological methods would appear to be apt for studies of the production of creative animation, where qualitative techniques can be used to collect data on the subjective experiences of a sample of animation practitioners.

However, intersubjectivity need not be seen as exclusive to research into the experience of animation production. After all, perception and interpretation of animation are also personal encounters with phenomena. While a positivist approach to human perception is well established and documented, it could be argued that any attempt to quantify the complex experiences that audiences have when observing animation will inevitably omit the depth and meaning of those experiences. As discussed in section 3.3, quantitative methods for accurate and deliberate measurement of observer responses to animation are sensible and appropriate to the nature of the research. For instance, measurements of observer judgement of emotion have been shown to be effective in facial expression research, where statistical analysis of data can be used to demonstrate the significance of findings. Nevertheless, these methods are dependent on the quantification of audience responses, and with dynamic facial animation it is difficult to see how every facet of those responses can be measured numerically. In reality, most of what we experience when observing animation can be more easily described in language, not in numbers. In this sense, a qualitative interpretivist approach to observer perception of facial animation is also fitting.

In the Emotional Avatars research, artistic methods are adopted in order to explore expression animation subjectively, and positivist empirical methods of quantifying observer judgement of expressions are used to provide a more objective evaluation of emotional expression choreography. Interpretive methods are integrated into the research framework in order to gather qualitative data, which in turn can provide further clues about the intersubjective interpretation of animation production and perception.

3.4.2 Qualitative research for facial animation

A qualitative research approach is adopted as the third component of the Emotional Avatars research framework. As shown in Table 3.3, the

Table 3.3: Qualitative paradigm characteristics for the Emotional Avatars research.

Paradigm	Qualitative
Ontology	Relativist
Epistemology	Interpretivism
Selected Methodology	Phenomenology
Research Material	Arts tools, visual stimuli
Validity	Research participants corroborate researcher interpretations, full transcripts made available
Reliability	Multiple sources, researcher's subjectivity and interpretation declared

chosen theoretical perspective is interpretivism, with phenomenological methods (based on data collection using diaries, interviews, and focus groups) used to investigate the intersubjective interpretation of animation practitioners and audiences.

3.5 The research framework and mixed methods design

It can be argued that, of the research paradigms discussed in the previous sections, none can be said to truly embrace researcher objectivity, as "even experimental science is based on the interpretation of the experiences and observations of the scientist" (Biggs, 2008), a view shared by Weber (2004). This point in itself could be considered controversial by some researchers, and represents a highly unnecessary philosophical diversion in this thesis. It does, however, shed light on a much more broadly accepted concept – that "no type of research can fully uncover its object" (Engles-Schwarzpaul, 2008). There will always be aspects of the 'object' that cannot be investigated using particular research approaches. In the context of facial animation production and perception, this point is no less valid. In fact, because the research questions reiterated at the start of this chapter highlight the need for both an artistic and scientific understanding of facial animation, the necessity for a mixed methods approach is perhaps all the more clear.

In order to understand the potential role and effect of EEC, it was proposed that an exploratory study of animation production would reveal the means and effect of choreographing emotional expressions. Discussion of the emerging performative paradigm of research – or research through studio-based practice – illustrated how structured research in the creative arts could be embraced to address this aspect of the project aim. Essentially, subjective interpretations and conclusions could be drawn regarding the animation of facial expressions, based on iterative and reflective practice. However, the project aim also stated that the subjective findings of the practitioner-researcher ought to be assessed based on evidence generated from research participants other than the practitioner. As a result, quantitative and qualitative paradigms were discussed in relation to the effect of choreographed expressions on observer perception, and the contextual interpretation of choreography by both animators and audiences. Overall, it is clear that performative methods are too deeply subjective and artistic to make general conclusions regarding the role or effect of choreography, although they can reveal meaning and form predictions. Additionally, neither quantitative nor qualitative methods alone can address the assessment of choreographed expressions, as variation in expression appearance has been shown to have universal, measurable effects, but expressions are also laden with context and meaning which can only be explored by considering experiential interpretations.

In other words, the tri-paradigm mixed methods approach proposed in this chapter is the most appropriate means of investigating the effect of emotional expression choreography holistically. As such, it is necessary to consider how these three paradigms fit together, and how the resulting, interconnected methods can be used to generate and collect data which will inform the overall conclusions.

3.5.1 Sullivan's framework of art practice as research

The theoretical research framework that underpins the Emotional Avatars methodology is based on Sullivan's (2009) framework for visual arts research. This framework (Figure 3.1) places visual art practice at the centre of research surrounded by empirical, interpretivist, and critical paradigms. Sullivan suggests that, rather than there being strict boundaries between these areas of research, the lines that bound each of the triangles in the figure should be considered 'bridges'. In this sense, the visual arts researcher can bridge the gap between, say, empiricism and art practice, in order to address conceptual research problems that can be investigated through the creation and critique of visual art.

This framework is applicable to the Emotional Avatars project when a relational method is identified, as in Figure 3.2. Here, Sullivan depicts the relationships between research paradigms and arts practice. As discussed previously, the Emotional Avatars research is predominantly concerned with

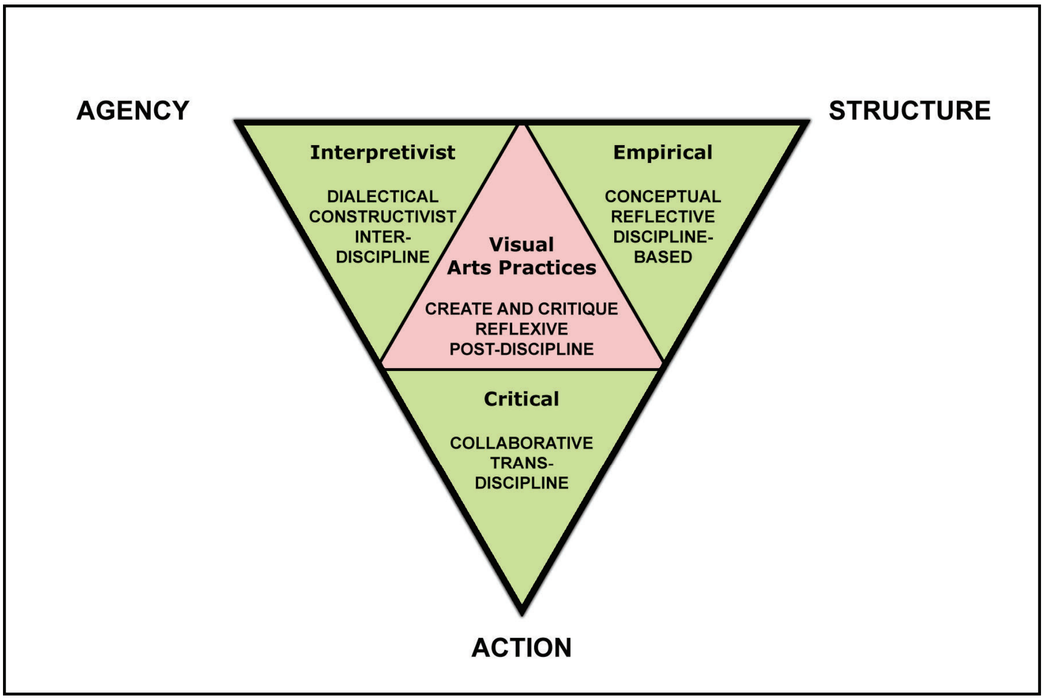


Figure 3.1: Framework for visual arts research as proposed by Sullivan (2009).

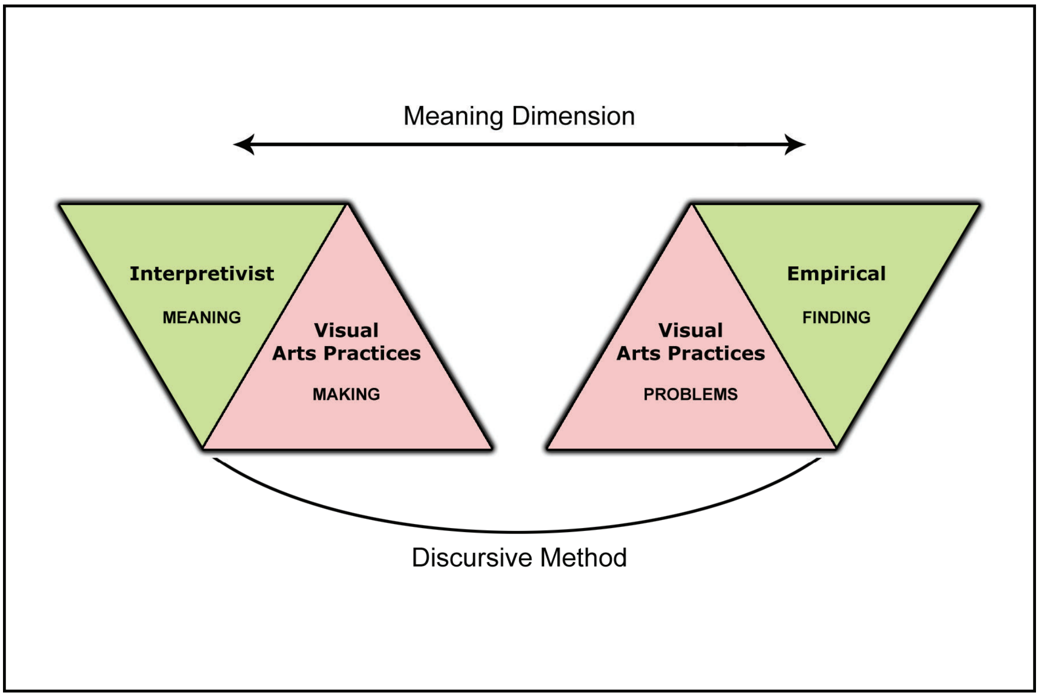


Figure 3.2: Theoretical relationships between visual arts practice and research approaches, as proposed by Sullivan (2009).

three distinct perspectives; the perspective of the practitioner-researcher during and after animation production (represented by the triangles of Visual Arts Practices), the perception of a general audience (represented by the Empirical triangle on the right of the figure), and the intersubjective interpretation of facial animation by practitioners and audiences (represented by the Interpretivist triangle on the left of the figure). As Figure 3.2 shows, these three research traditions are bound together within Sullivan's framework in what he terms the 'Discursive Method', which is principally concerned with the investigation of meaning. Visual arts practice – in the case of Emotional Avatars, the creative production of facial animation and exploration of facial dynamics – is seen as the core of the discursive method. When it comes to exploring, developing, and testing the concept of emotional expression choreography, two relationships are clearly apparent within this method. Firstly, the relationship between art practice and empiricism is seen as a relationship between investigating problems (through practice) and finding answers (through empirical research). In the context of Emotional Avatars, this relationship provides a framework for tackling the problem of EEC through studio-based animation practice, and finding out whether the practitioner's explorations of choreography will impact on observers through the generation and analysis of quantifiable data. Secondly, the relationship between art practice and interpretivism is seen as a relationship between making (through practice) and an exploration of meaning (through interpretivist research). For the Emotional Avatars project, this relationship provides scope for an investigation of the more nuanced meaning of EEC, firstly through the reflective production of facial animation, and secondly through qualitative studies of animation interpretation. This research framework suggested by Sullivan and adopted for the Emotional Avatars project essentially places art practice at the heart of the research. Empirical and interpretivist traditions are seen as relational extensions of practice; as part of a broader visual arts research method that is ultimately concerned with investigating meaning. While this does constitute an appropriate base research methodology in itself – one which can be rooted in animation practice while also incorporating quantitative and qualitative modes of research – it is crucial that a more detailed methodological design is developed; one which directly addresses the specific research questions of the Emotional Avatars project.

3.5.2 The convergence model combined with the sequential exploratory design

In traditional mixed methods designs, both quantitative and qualitative methods are employed in order to address the research questions. However, the practice-led research approach of the Emotional Avatars project incorporates a third research paradigm: performative research. As such, an adaptation of an existing mixed methods design framed by Sullivan's (2009) discursive method is required.

The first mixed methods design worth noting is the convergence model of triangulation (Creswell, 2003). This design consists of two studies – one quantitative and one qualitative. The quantitative and qualitative data is collected and analysed concurrently and independently, with each data set

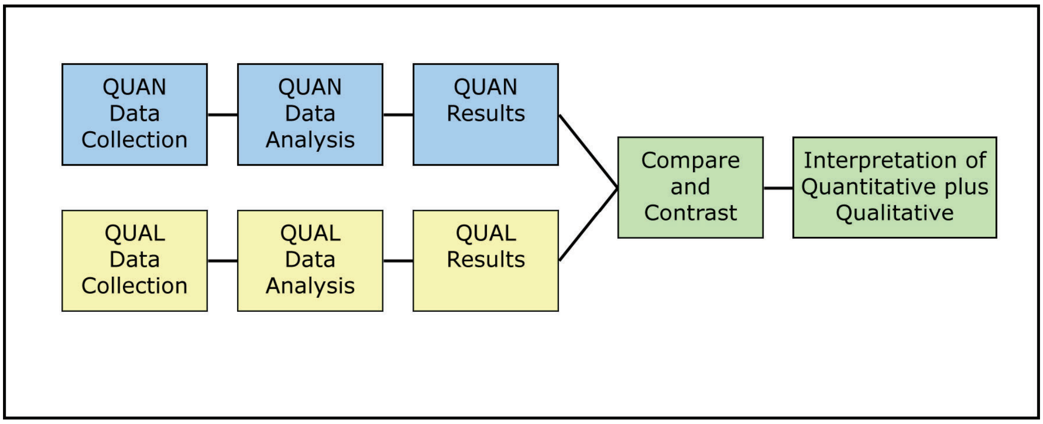


Figure 3.3: The convergence model of triangulation, adapted from Creswell and Plano Clark (2007). Quantitative and qualitative data is collected, analysed, and interpreted independently and concurrently, before the results are connected and an overall interpretation is made.

addressing different but related research questions. The two data sets are then merged to provide a holistic interpretation of the results, whereby analysis of the quantitative data provides evidence of measurable phenomena, and analysis of qualitative data provides interpretive explanations (see Figure 3.3). The rationale for using this model within the Emotional Avatars methodology is to bring together the strengths of quantitative and qualitative methods, enabling generalization of audience perception as well as an interpretive study of animation production and perception (Creswell, 2003; Creswell and Plano Clark, 2007).

Although it is not advisable to blend two mixed methods designs (Creswell and Plano Clark, 2007), the inclusion of performative research methods prior to quantitative and qualitative studies is crucial to the overall Emotional Avatars methodology. While the quantitative and qualitative methods are carried out concurrently, the findings of artistic animation inquiry feed into these subsequent studies, setting up a sequence of research methods. Furthermore, the performative methods are used as a means of

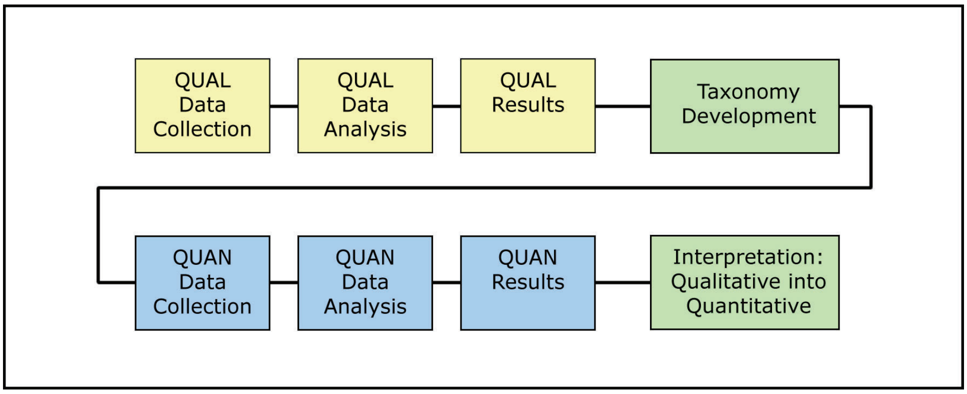


Figure 3.4: The taxonomy development model of sequential exploratory design, adapted from Creswell and Plano Clark (2007).

exploring the potential of EEC, establishing variables, and making predictions about artistic production and audience perception. As such, the overall mixed methods design including performative, quantitative, and qualitative methods fits with the sequential exploratory mixed methods design (Creswell, 2003). The mixed-methods sequential exploratory design consists of both a quantitative and a qualitative study, which are sequenced so that one study informs the development and execution of the subsequent study. For instance, qualitative data can be initially collected in order to explore a particular phenomenon, before quantitative data is collected to build upon the findings of the qualitative study. This variation of the sequential exploratory design is known as the taxonomy development model (see Figure 3.4). In this model, the qualitative method is used to identify variables and develop taxonomy, while the quantitative study tests results (Creswell and Plano Clark, 2007).

For the Emotional Avatars methodology, the sequential exploratory design can be used as a template for incorporating performative animation research as an initial study prior to the application of the convergence model

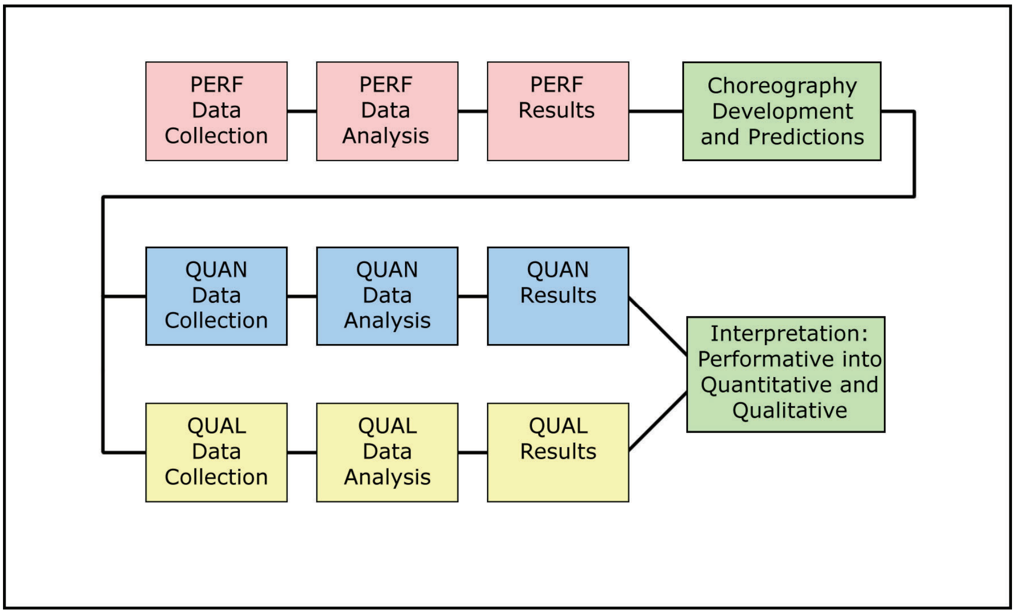


Figure 3.5: The Emotional Avatars mixed methods design adhering to Sullivan's (2009) visual arts research framework, and incorporating both the convergence model of triangulation and the taxonomy development model of sequential exploratory design (Creswell and Plano Clark, 2007).

(see Figure 3.5), which consists of concurrent quantitative and qualitative studies. Through performative research and analysis, animation concepts are explored, temporal variables clarified, and potential meanings proposed. This in turn connects to the concurrent quantitative and qualitative studies. Overall, a clear path to holistic results can be traced, with performative, quantitative, and qualitative findings all taken into account when the final assessment of EEC is conducted.

3.6 Performative research methodology

The first phase of research concerned an investigation of facial animation rooted in creative practice, the results of which are presented in Chapter 4. The purpose of the following practice-based methodology was to address the first research question - *can creative animation practice reveal a means of choreographing believable emotional facial expressions.* For the purposes of this research, the performative paradigm was adopted, with the researcher taking on the role of practitioner-researcher. In order to structure the studio-based research and ensure that data was collected during the creative process, a range of appropriate data recording and analytical methods were adopted.

3.6.1 Inquiry cycle method

To explore the nature of EEC through animation practice, iterations of animation were produced using a modified inquiry cycle (See Figure 3.6) to structure studio work. At this stage of the performative research, the focus was fully on the artistic production and subjective evaluation of animation throughout the creative process. This particular method was developed to cater for the Emotional Avatars project, but was based on the 'enquiry cycle' method as used by Fenton (2007) and discussed by Haseman (2008). Additionally, the Kolb learning cycle (Kolb, 1984) and Gray and Malin's (2004) adaptation of McAleese's (1999) reflective journaling (see Figure 3.7) were both used as a basis in the refinement of an appropriate cycle of inquiry for the proposed animation research. The Emotional Avatars variation of the inquiry cycle (along with results) has been discussed in previous publications (Sloan, Robinson and Cook, 2009c; Sloan et al., 2010a; Sloan et al., 2010b). In essence, the inquiry cycle structures and lays bare the iterative, artistic process of generating animation using traditional tools and approaches (the

Planning phase), producing animation based on preparatory work (the Action phase), observing and reflecting on animation (the Post-action phase), and critiquing the quality of the produced animation (the Evaluation phase). The cycle is then repeated, and more refined animations are produced.

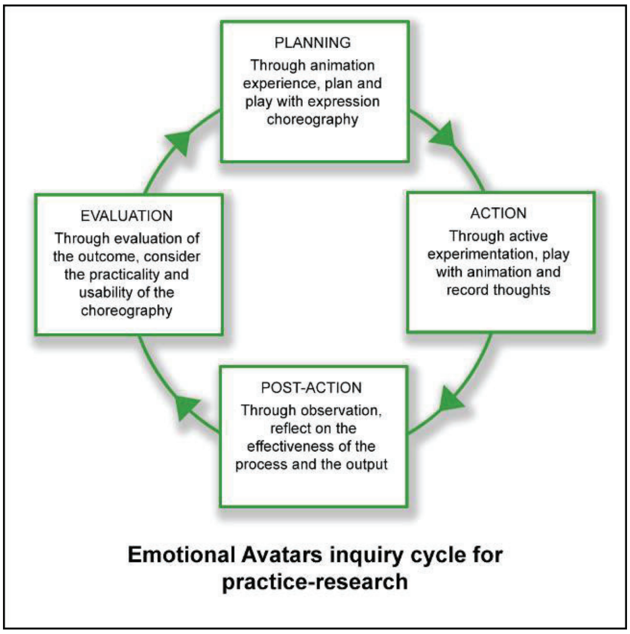


Figure 3.6: The four stages of the Emotional Avatars inquiry cycle, which is used to generate successive iterations of emotional facial expression animation through reflection-in-practice.

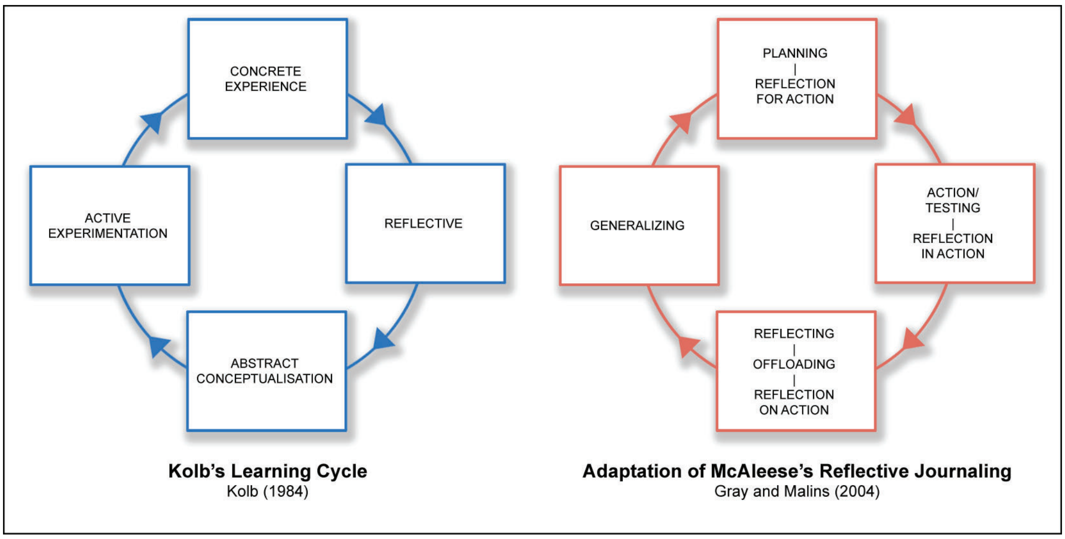


Figure 3.7: Kolb's learning cycle and Gray and Malin's adaptation of McAleese's reflective journaling were both influential in the development of the Emotional Avatars inquiry cycle.

3.6.2 Tools for reflection-in-practice

In order to generate and record data through the application of the inquiry cycle, a number of tools were available to the practitioner-researcher. For this project, the tools selected were both relevant to the practice of animation and convenient to use without disrupting the creative process. Each of the tools used were linked to a stage in the inquiry cycle (see Figure 3.8). Firstly, sketchbooks were used to record output from both the *Planning* and *Action* stages. For the animation of choreographed emotional facial expressions, each emotional expression choreography was planned and explored visually with annotations. For instance, when exploring the temporal unfolding of EEC, every sequence of movement was laid out visually through the sketching of key poses and breakdowns. Sketches were annotated to demonstrate the planned timing and strength of nuanced movement within the face. Where interesting influences from reference materials and resources

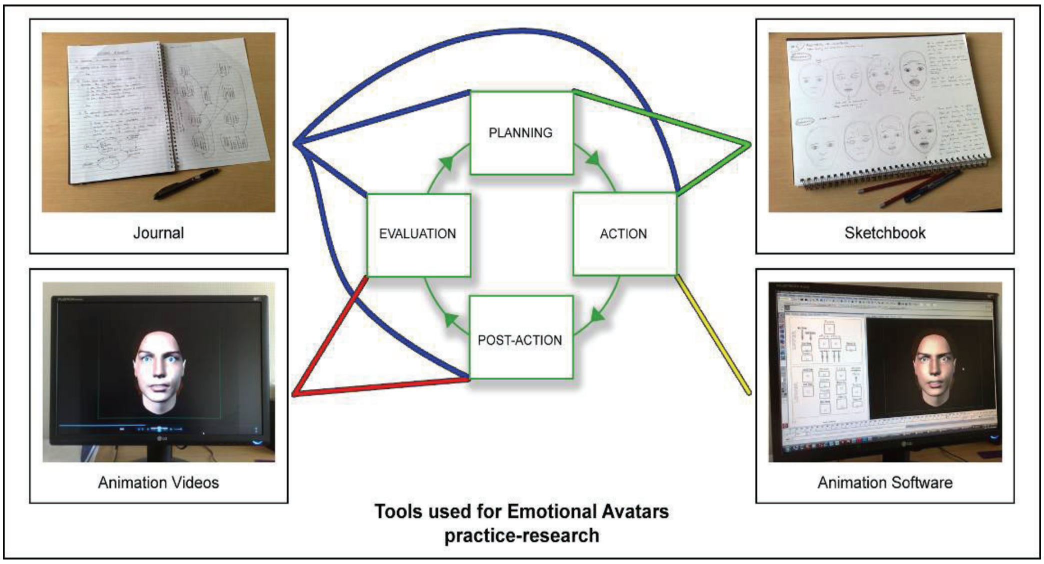


Figure 3.8: The four main tools used by the practitioner-researcher and how they related to the four stages of the inquiry cycle.

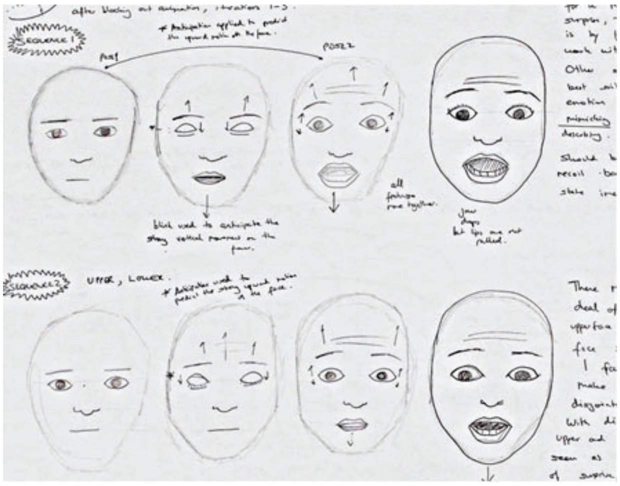


Figure 3.9: Scan from a sketchbook used to plan choreographed expressions based on sequence manipulation. Annotations and symbols are used to describe the movement and reasoning behind decisions.

impacted on the planning, these were noted beside the relevant drawings (see Figure 3.9). For example, Anticipation was applied in the planning of surprise expressions through the use of a blink immediately before the strong upward motion of the upper lids and brows. When actively producing animation, quick notes or corrections were added to the sketchbook. Plans may even have been reworked (effectively taking a step back in the cycle) if animation practice during the *Action* stage immediately presented problems. Animation software (Autodesk Maya) was the main tool used to explore the effect of choreography in practice, and directly related to the *Action* stage. A record of creative experimentation with the software was easy to keep, as a new file could be saved for each iteration of animation. This enabled a closer post-production examination of the creative process through evaluation of the specific changes to animation made during production. From the animation software, animation videos were rendered. These videos were used as a tool by the practitioner when undertaking *Post-action* reflection. Observation of the videos allowed for a non-interactive personal interpretation of the animation produced, helping the practitioner to determine the quality of the output, i.e. whether it was representative of the intended emotion, and whether it was suitably authentic. As with the animation software, the videos were also used as a chronological log of animation development, highlighting changes, issues, and the overall applicability of emotional expression choreography. Finally, journaling as a tool was used to record the thoughts of the practitioner throughout successive iterations of the inquiry cycle. Of all the tools used, the journal was the most detailed in terms of the personal development of work and interpretation of the choreography exploration. The journal was carefully structured to show each stage of the cycle, for however many iterations were produced and for each emotional expression choreography. By taking on a deliberate structure instead of using an open ended journal, the evaluation and analysis of notes taken in the journal was easier to undertake, and links between thoughts recorded in the journal and development shown in the sketchbook, files, and videos was easier to establish. The journal template used by the practitioner-researcher is provided in Appendix IV.

The base inquiry cycle and related tools for reflection-in-action provided a framework for iterative practice-based research, but the Emotional Avatars adaptation of the cycle did not cater for in-depth reflection on practice. In order to truly step back and reflect on multiple iterations of creative practice, a post-production stage of reflection-on-action was required.

3.6.3 Tools for reflection-on-practice

As identified earlier in this chapter – in the discussion of reflective practice – adequate reflection on practice requires sufficient time to be allocated after the period of activity. The inquiry cycle method was effectively used as a means of structuring studio practice and ensuring that sufficient data was recorded for future reflection. Once a performative study was completed, an analytical process of detailed reflection was conducted in order to reveal and expose the subjective findings of the practitioner-researcher, and to formulate predictions for subsequent quantitative and qualitative studies. This process began with the reduction and incorporation of data into an easily accessible matrix, the writing of structured reflections for each case, and finally the execution of an analytical procedure (based on the work of both Ekman, and Thomas and Johnston) in order to declare predictions.

3.6.3.1 Multimedia matrix

Firstly, each performative study of EEC resulted in a substantial amount of written and visual data. In order to aid efficient reflection (and also to present all data in a more accessible way – a key aspect of the performative paradigm validity) a template for a multimedia matrix was designed (see Figure 3.10). This matrix was designed using Adobe Flash, which proved suitable for the incorporation of interactive and temporal data (image magnification, text scrolling, and video playback). The multimedia

Figure 3.10: Screenshot of the multimedia matrix which was used as a data reduction tool during reflection on practice.

matrix, which contains the data for two performative studies (discussed in Chapter 4) is included in Appendix V.

3.6.3.2 A method of structured reflection

In order to carry out detailed reflection on the process of exploring choreography and producing choreographed expression animations, theories and models of education and reflection were considered. John's (1995) model of structured reflection (MSR) – which previously influenced Fenton (2007) – was one of the key models used as the basis for reflection on studio-practice. John's model was used predominantly in nursing practice, enabling practitioners to focus and reflect on experience through the use of cues. Also from the domain of nursing, Taylor's description of technical reflection (2006)

Key components of John's MSR (1995)

1. Description
2. Reflection
3. Influencing factors
4. Alternative strategies
5. Learning

Key components of Taylor's technical reflection (2006)

1. Assessing and planning
2. Implementing
3. Evaluating

Key components of Kolb's learning styles (1984)

1. Active experimentation (planning)
2. Concrete experience (doing)
3. Reflective observation (reviewing)
4. Abstract conceptualisation (concluding)

Figure 3.11: Resources used to formulate the Emotional Avatars method of structured reflection.

proved to be a valuable resource in forming an appropriate method of structured reflection on animation production. In addition, Kolb's learning styles (1984) were once again considered in order to rationalise what was learned and through what means. The key components of these three concepts are shown in Figure 3.11. In forming a method of structured reflection suitable to the specifics of the Emotional Avatars performative research, each of the three concepts were incorporated into a seven stage rationale for structured reflection (see Figure 3.12). The final list of structured reflection cues is provided as Appendix VI. The Emotional Avatars structured reflection method was used in conjunction with the multimedia matrix in order to produce textual accounts of practitioner experience, which in turn informed the refinement of findings as discussed in the next section.

Stage 1: Description

An overview of the current reflection is provided drawing attention to key points of interest. The problem is stated, and how the expression may be treated in nature and animation is considered.

Stage 2: Reflection on planning

Covers issues identified in planning, including various iterations of development.

Stage 3: Reflection on action

Cues relate to the specific task goals, task progression, and the practitioner's experience undertaking the task.

Stage 4: Reflection on post-action

Covers the practitioner's reception and observation of resulting animation.

Stage 5: Influencing factors

Reflection on the internal and external factors which impacted on decision making and outcomes.

Stage 6: Alternative strategies

Covers what other choices were available and the potential repercussions of alternative decisions.

Stage 7: Evaluation

Covers an overall evaluation of the work, judgements, and the wider context. Includes subjective rating of choreographies derived from practice-research and reflection.

Figure 3.12: The rationale for the Emotional Avatars method of structured reflection, based on the work of Johns, Taylor and Kolb.

3.6.3.3 A procedure for emotional expression animation and analysis

In Chapter 2, a review of the related literature in emotional psychology and animation production revealed respective theoretical and practical codes which could be applied to the Emotional Avatars research. Ekman's (1992) basic emotion characteristics (section 2.1.2.1) consisted of nine principles of emotion, each of which could be expanded upon by studying the supporting psychology literature. Consideration of these characteristics not only assisted the animation practitioner in the production of emotional expression animation, but also provided a procedure for systematically analysing animation output within the context of psychological theory. Thomas and Jonhston's (1981) principles of animation (section 2.2.1) were generally regarded as the fundamental codes and conventions of traditional animation production. The principles of animation informed the development of emotional expression animation, in particular by focussing the practitioner's attention on aspects of animation that could ultimately affect audience interpretation and suspension of disbelief (such as Timing, Anticipation, and Overlapping Action).

It was therefore clear that both Ekman's characteristics and Thomas and Johnston's principles were of particular relevance to the practice-centric nature of the Emotional Avatars project. As such, they were selected as the core evaluative components of a procedure for emotional expression animation and analysis (see Figure 3.13). This procedure details the complete process for Emotional Avatars performative research; producing animation (the inquiry cycle method), reducing the resulting data (the multimedia matrix), practitioner reflection (the method of structured reflection), and evaluation of animation output framed by an understanding of psychology (Ekman's basic characteristics) and animation practice (Thomas and Johnston's principles). The latter two stages of this procedure were used to formalize psychological context (the nature of the expressed emotion) and artistic context (the intuitiveness and practicality of choreography), and to

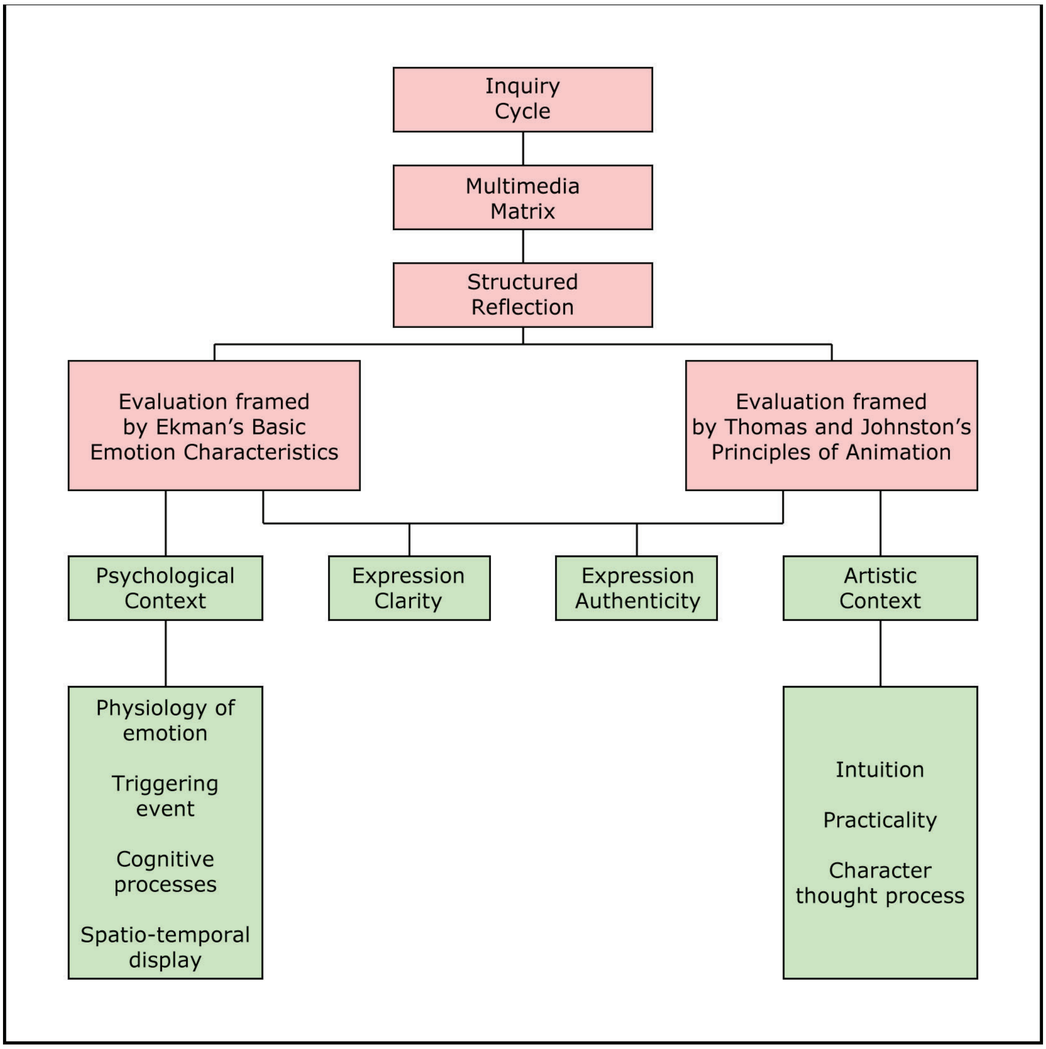


Figure 3.13: The procedure for emotional expression animation and analysis, followed in order to produce and evaluate emotional expression animations through practice-based research.

make predictions as regards the clarity and authenticity of choreographed emotional expression animations.

The procedure for emotional expression animation and analysis shown in Figure 3.13 ensured that each stage of the highly subjective process of key frame animation was exposed. This was crucial, as it meant that the procedure followed by the practitioner-researcher could be closely and critically examined, which in turn served to validate the research outcomes and conclusions. In Chapter 4, studies conducted through animation practice shall be discussed which adopted this procedure in order to come to firm conclusions on the role and effect of EEC.

3.6.4 Exposition of animation process and output

The previous sections laid out the methodology for the performative aspects of the Emotional Avatars research. In order to address the issue of validity in practice-based research, a further methodological consideration was the role of exhibition. In practice-based creative research, the production of exploratory and conceptual artwork is inevitable as the practitioner engages with the research questions. The evidence of creative research could consist of audio/visual exploration of ideas, sketchbooks, developmental concept art, visualization of underlying concepts, and finished art pieces. It is recognized that exhibition - or, more accurately, exposition - of the creative process is an effective means of communicating the successes and failures of the research project, to the point that it could even form part of formal assessment. As Newbury (1997) discusses, the distinction between professional exhibition and research exposition is an important one:

> "I would argue that this difference is carried throughout the research process, whether the exhibition of work is built into stages of the research process or simply appears at the end. It also carries implications for any publications that may be attached to such exhibitions. These also must carry or attempt to explore a critical method of evaluation - a far cry from the professional norm, sadly, which is very often journalistic and self congratulatory."
> (Newbury, 1997, p 23)

For the Emotional Avatars project, exposition was seen as a means of opening up the creative methods and findings to criticism, allowing for peer and public review of the research and artistic outcomes. Ultimately, exposition was used to communicate the research throughout the life of the project, to collect feedback from peers, experts, and the general public. Unlike the experimental method – which returned scientific evidence of specific perceptual measures – exposition allowed for interaction between the practitioner-researcher and visitors to the exhibition. Various means of recording the thoughts and opinions of visitors were adopted, for instance visitor comments books, recorded conversation, blank posters for leaving visual thoughts, and ballot boxes which were used by visitors to vote for particular images or animations. In terms of the project research questions, exposition was specifically seen as a means of exposing the concept of EEC, the exploration of the choreography concept through planning and reflection, and the animation produced as a result of the research. With exposition invites sent to students, educators, researchers, and practitioners of creative art and animation, the Emotional Avatars expositions not only provided a means of public critical evaluation, but also served as an important feedback loop for the practitioner-researcher, informing further iterations of research through creative practice. Details of expositions held prior to the writing of this thesis are discussed in Chapter 4.

3.7 Quantitative and qualitative research methodologies

In contrast to the performative methodology discussed in the previous section, which was designed explicitly for the Emotional Avatars research, existing quantitative and qualitative methods were deemed appropriate for the associated research questions. For the quantitative research aspect of the project, controlled experiments designed to measure observer perception (such as the typical judgement approach detailed in 3.3.2) were used. Here, the stimuli which were assessed by observers were the resulting animations of the aforementioned performative methodology. Details of the experimental methods, analysis, and results are presented in Chapter 5. For the qualitative angle, interpretive phenomenological analysis (IPA) and focus groups were selected for studies of animation production and perception respectively. The precise details of these methods, the analytical procedures, and the qualitative results are discussed in Chapter 6.

3.8 Chapter summary

In this chapter, the theoretical framework and overall methodology of the Emotional Avatars project has been explained in depth. A mixed-methods design incorporating three paradigms of research – performative, quantitative, and qualitative methods – was described and justified as being appropriate for the research questions posed in Chapter 1. It was shown that performative methods could be adopted to enable an artistic investigation of emotional expression choreography. A clear structure of method (inquiry cycle), analysis (the use of a multimedia matrix and structured reflection) and validation (exposition) was proposed as a performative methodology for creative exploration of emotional expression choreography. The execution of this performative methodology (including research findings) is described in Chapter 4. To measure and assess the perception of choreographed emotional expression animation by a general observing audience, a more scientific, quantitative methodology was proposed. The details and results of several experiments that follow this empirical methodology are described in Chapter 5. Finally, qualitative methods were put forward as being an appropriate means for an investigation of the intersubjective interpretations of emotional expression choreography by practitioners and audiences. The design and results of interpretive studies of animation production and perception are described in Chapter 6.

Overall, the justification for and structure of a practice-led, mixed-methods design were addressed in this chapter. By laying bare the performative methodology, the practice-based research element of the project can be scrutinised, critiqued, and repeated. The analytical procedure which the practitioner-researcher followed to investigate the effect of EEC and form conclusions was detailed, allowing for a more transparent record of the production and subjective evaluation of animation. The relationship between performative, quantitative, and qualitative research approaches was presented, demonstrating how a holistic interpretation of the role and effect of EEC could be accomplished. In the following chapters, the findings of these three areas of research are discussed.

Chapter 4
Creative animation production:
inquiry through reflective artistic practice

In the previous chapters, animation practice as a means of generating knowledge was discussed. This led to the proposal of a performative – or practice-based – methodology, designed to enable artistic exploration of emotional expression animation. As an emerging field, there is currently no standardised practice for reporting or publishing the findings of performative research. Indeed, the unique qualities of arts-based studies (and the range of artistic methods employed throughout the visual arts) may well dictate that standardisation or formalisation of performative research publication is not only impossible, but undesirable. The incorporation of performance and exposition into the research can, for instance, outweigh the need for traditional written publication. In some cases, the process and output of research may be entirely contained within the artefacts produced – in other words, the art work *is* the thesis (see Gray and Malins, 2004, pp.165-166). It is not inconceivable that many practice-based research projects will exclusively treat the artwork as the research output, doing away with a written thesis all together (as theorised by Frayling, 1993). The performative methodology for an exploration of EEC proposed in Chapter 3 implied a proportion of written work, for instance in the recording of thoughts and the reflection on practice. Nevertheless, the majority of the research conducted using this methodology was rooted in studio practice. Due to the nature of the artworks – animations produced iteratively under different conditions – presentation of both the process and output could not be contained entirely within a written thesis. As such, and as discussed in Chapter 3, exposition formed a crucial part of this research. Nevertheless it was appropriate that the findings of the performative methodology – including details of exposition – would be contained within the written thesis; particularly so as the overall methodology called for the application of methods traditionally reported in written text.

In this chapter and the associated appendices, the life span of the performative research is reported in full. This research started with an initial investigation of acted and naturalistic expressions, which were studied in order to develop the concept of EEC. The researcher then created custom facial animation tools which could be used to explore EEC in more detail. The major studies of emotional expression animation (following the performative methodology) were then conducted, and findings are reported in this chapter. Finally, major expositions and public displays of the work are reported in the closing sections. The accompanying appendices are vital to this chapter. The artistic data generated throughout the project – including sketches, animation, journals, and exposition – are contained on the DVD. The multimedia matrix used to analyse the arts-materials can also be found here. In addition, supporting texts which expand on the work discussed in this chapter are included in the appendices.

4.1 New reference material and initial practice-based studies

Prior to the commencement of the studio-based research following the performative methodology, a series of studies were conceived which would serve to provide the practitioner-researcher not only with valuable, original reference material, but also with experience in the generation and observation of emotional facial expressions under different conditions. Although a wealth of reference material on emotional expressions (identified in Chapter 2) already existed, it was deemed necessary that this material be supplemented by new videos and sketches produced by the researcher. These new materials would compliment the existing resources, and would provide the practitioner-researcher with the extensive referential material required for developing the concept of EEC. Firstly, the practitioner-researcher sought to generate videos of naturalistic and acted expressions, and to conduct an arts-based study of the resulting videos.

4.1.1 Generating naturalistic expressions

The aim of the first study was to capture video of genuine emotional expressions – in other words, expressions of felt emotions, rather than posed expressions of emotion. As discussed in Chapter 2, many studies of emotional expression are founded on the use of posed or acted expressions, so a library of *genuine* expressions was regarded as essential to the performative methodology. To achieve this, a method of inducing emotion in participants was developed based on studies reported by Philippot (1993) and

Gross and Levenson (1995). The procedure for generating and assessing the naturalistic expression videos is covered in detail in Appendix VII. Video clips of participant emotional expressions were generated by exposing the participants to tested emotionally evocative audio-visual stimuli. While genuine emotion is indeed difficult to recreate in a laboratory environment, steps were taken to ensure that the setting was as natural as possible without compromising the visual clarity of the recorded videos. Ten female respondents took part in this study. Female participants were selected as previous studies have shown that women can be more emotionally expressive than men (Kring, 1998). Ten participants was deemed sufficient, as the goal was to explore in detail the movement of naturally occurring expressions, rather than attempt to investigate the general appearance of expressions. This experiment was initially reported in Sloan et al. (2008).

4.1.1.1 Observational study of naturalistic expressions

In order to break down the naturalistic expression videos (examples shown in Figure 4.1) and extract potential elements which could be 'choreographed', the practitioner-researcher engaged in a period of observational sketching using the recorded expression videos as reference material. Throughout this process, the key literature regarding the appearance of expressions in nature (e.g. Ekman and Friesen, 1975; Faigin, 1990) was referred to as an aid in recognising common expression components. As discussed in Appendix VII, from a complete list of two-hundred and thirty-two captured expressions, thirty-six were selected for further study. These thirty-six videos consisted of the six most representative clips for each emotional expression (happiness, sadness, anger, fear, disgust, and surprise) all of which were supported by participant self report of emotion.

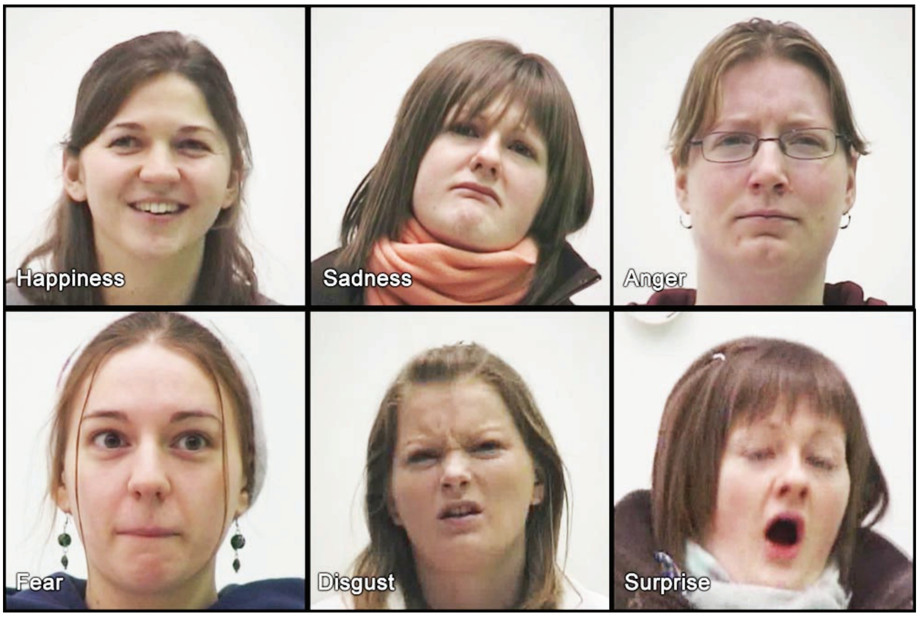


Figure 4.1: Stills from six of the naturalistic expressions of emotion.

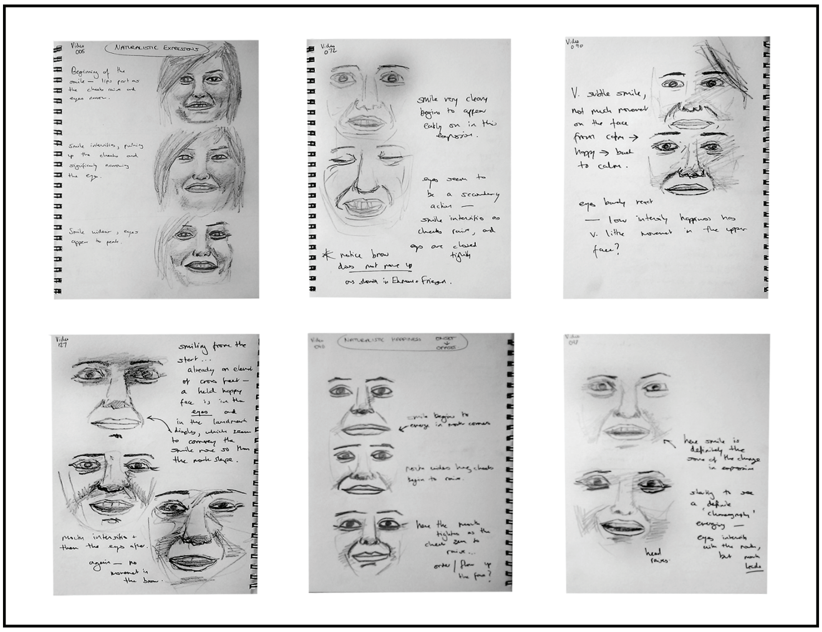


Figure 4.2: Excerpts from the sketchbook depicting drawings of naturalistic expressions of happiness.

Firstly, drawing expressions of happiness (Figure 4.2) revealed a trend in terms of upward motion on the face as happy expressions emerged. Starting with the mouth, it was observed that the mouth corners would often tighten prior to the broadening of the smile, the raising of the cheeks, and finally the squinting of the eyes. This observation was in line with the literature which indicated a temporal order to genuine happy expressions (Messinger et al., 2001). In addition, the brow remained fairly static in the drawn expressions while the area around the eyes would narrow, often accompanied by squinting or crows feet. This was consistent with descriptions of distinct expressions of happiness (Ekman and Friesen, 1975). The importance of facial landmarks was emphasised; in particular the dimples around the smile. Despite a quick movement from the neutral to the peak expression, this study indicated that an investigation of EEC could be based on the temporal order of distinct facial movements The second naturalistic expression, sadness, appeared to be held for prolonged periods – particularly in the upper face (see Figure 4.3). While the brows were pulled together and the eyes narrowed – often for the full duration – the lower face was observed to fluctuate more rapidly. Strong intensification of the mouth led to dimples and other landmark lines appearing around the lower face. Lip biting as well as the sliding of the jaw may have indicated suppression of sadness in the lower face in these examples. In one video, the upper face was clearly shown to intensify before later intensification in the mouth area, which then transformed into the full expected expression of sadness. In many ways, these sad expressions seemed to have a reverse flow *down* the face when compared with happy expressions. Prolonged holding of muscles in certain

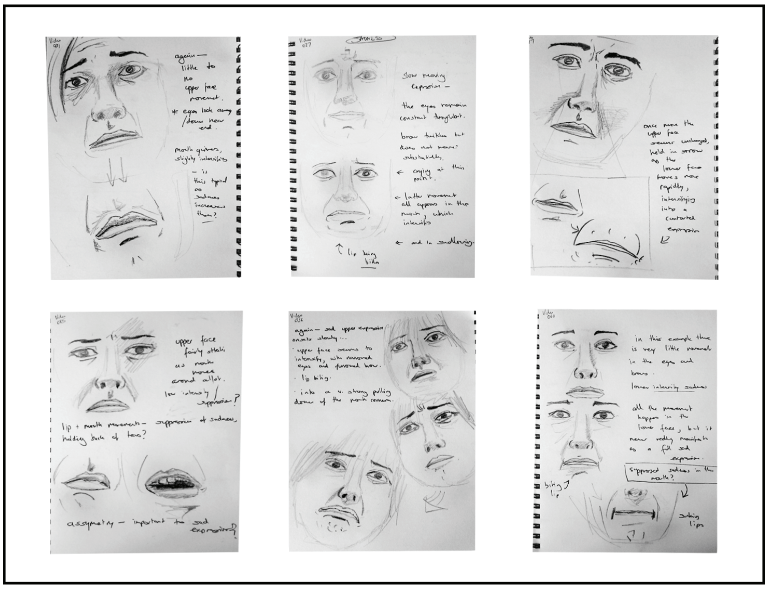


Figure 4.3: Excerpts from the sketchbook depicting drawings of naturalistic expressions of anger

facial regions indicated that emotional expression choreography may require scope for configuring the duration of regional expressions, as well as the sequence of regional movement.

In expressions of anger and fear, sketching the dynamic expressions highlighted the expressiveness of the eyes and upper face during controlled emotions. In most of the expressions of fear (which were generally perceived as mixed emotions by observers), the lower face was static or frozen while the upper face consisted of raised brows, tightened lids, and averted gaze (see Figure 4.5). Similarly, the relatively mild expressions of anger (see Figure 4.4) contained subtle movement in the upper face, but predominantly strained muscles around the mouth. In terms of choreography, then, these examples suggested that one potential element of emotional expression choreography could be the role of held or delayed movement, allowing for one area of the face (in this case the eyes and brows) to dominate an expression of emotion.

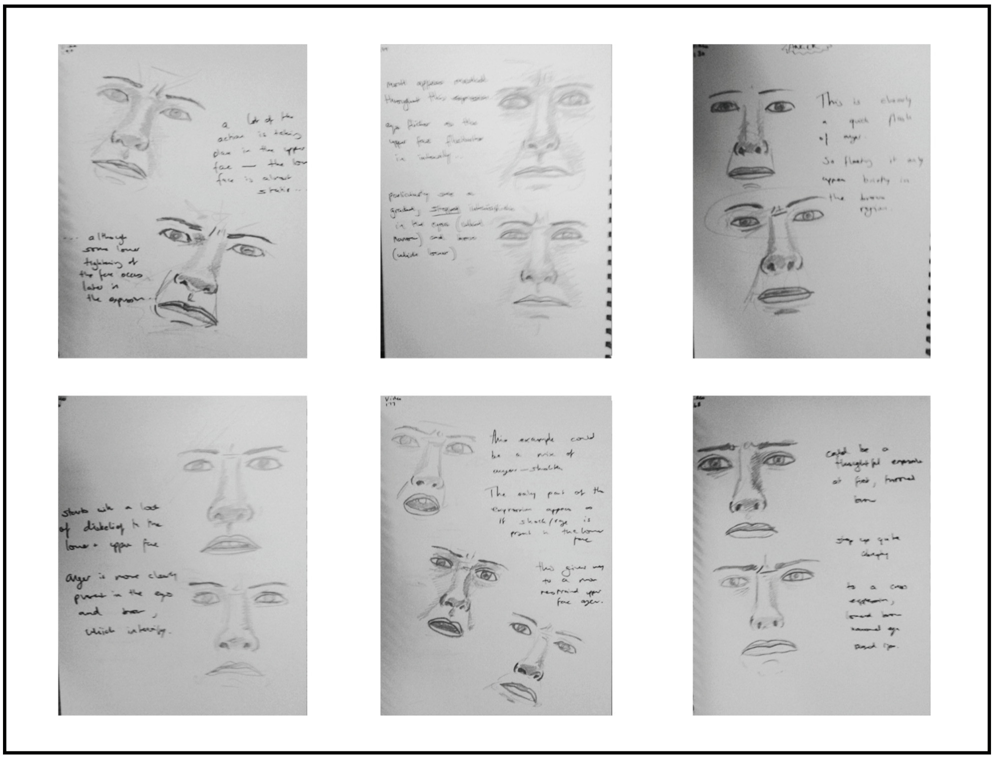


Figure 4.4: Excerpts from the sketchbook depicting drawings of naturalistic expressions of anger.

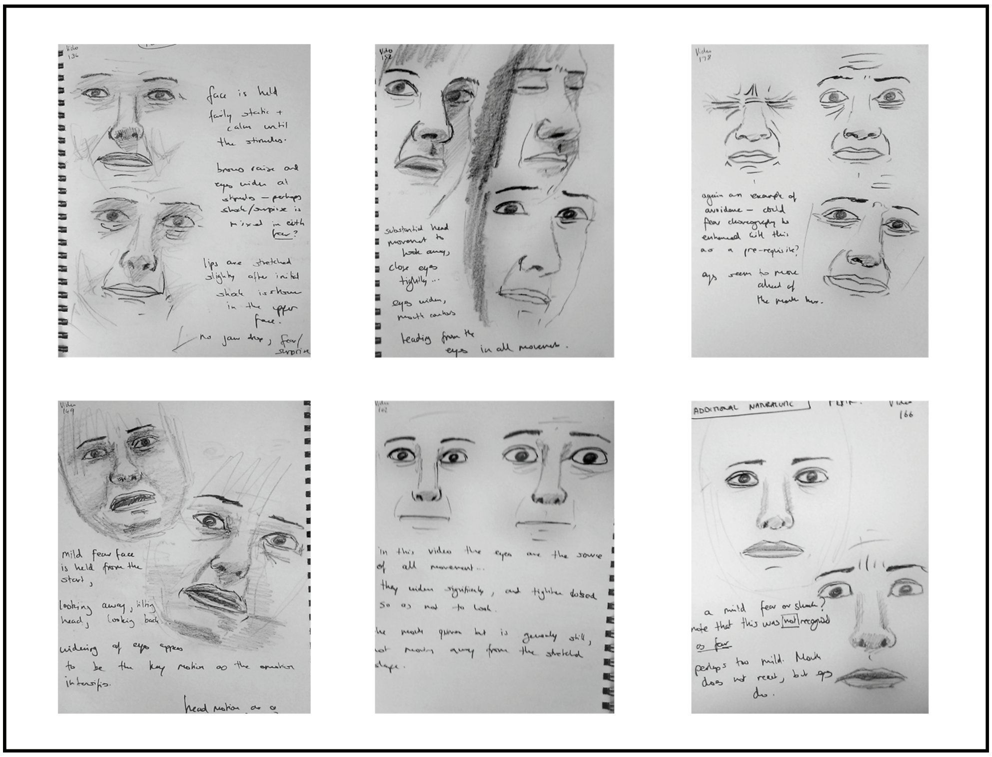


Figure 4.5: Excerpts from the sketchbook depicting drawings of naturalistic expressions of fear.

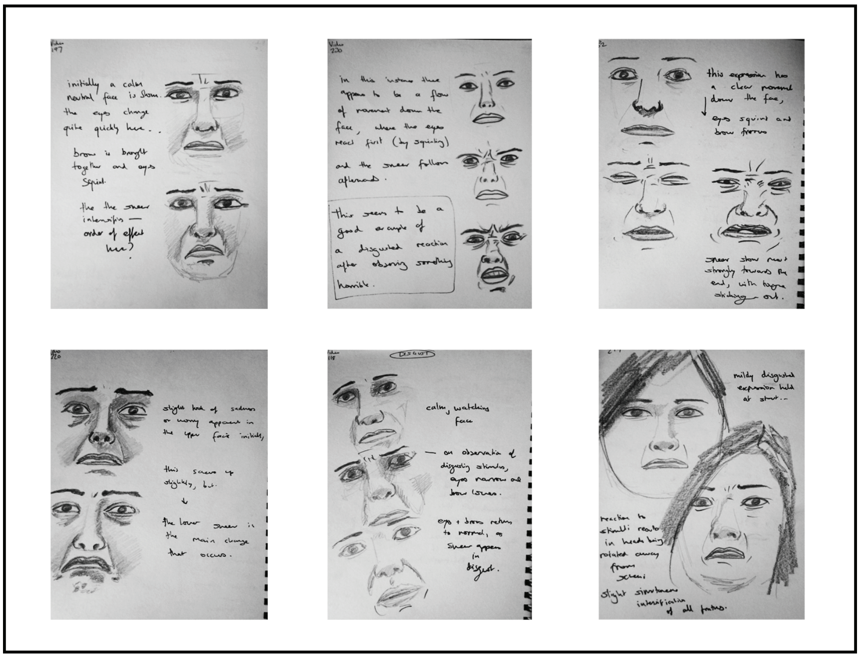


Figure 4.6: Excerpts from the sketchbook depicting drawings of naturalistic expressions of disgust

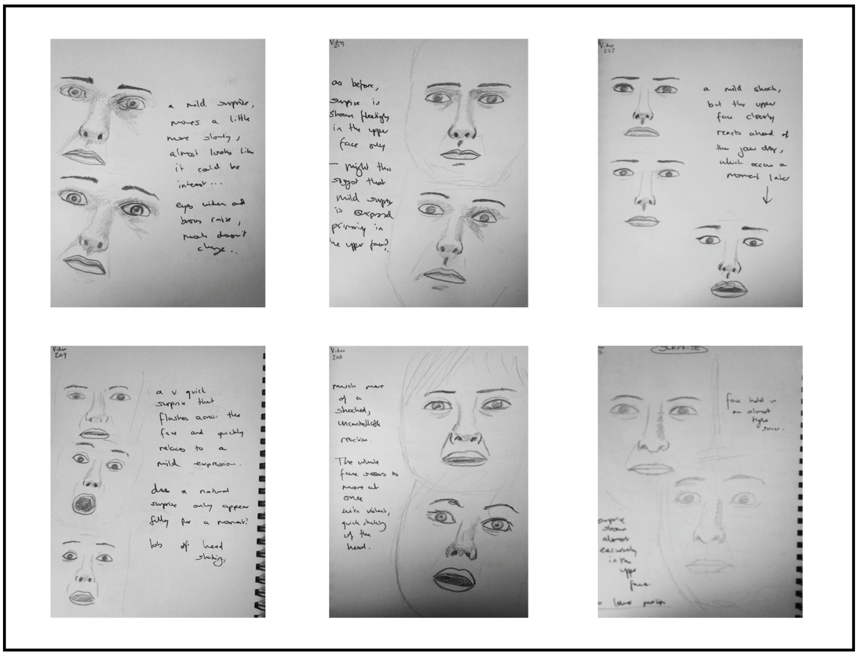


Figure 4.7: Excerpts from the sketchbook depicting drawings of naturalistic expressions of surprise.

The final two naturalistic expressions which were explored in the sketchbook were disgust (Figure 4.6) and surprise (Figure 4.7). Again, the timing of regional facial movements was a commonplace feature of these videos. In the majority of the disgust expressions, the sketches highlighted an often intense reaction in the eyes and brows prior to the typical sneer expression in the mouth region. The severity at which the various regions moved emerged as a potential element of EEC. For instance, the muscles of the brows, eyes, and mouth could potentially be choreographed with preset severities to enhance the believability of a disgust expression. Primarily, though, the temporal unfolding of expressions was the stand-out element of these expressions. In some of the surprise expressions, for instance, the eyes and brows appeared to express shock marginally ahead of a jaw drop, whereas the more exaggerated surprised reactions moved so quickly that the whole face seemed to shift simultaneously. As such, the observational study of naturalistic expressions revealed that the sequence, timing, duration, and severity of regional movements were the most promising concepts to explore in an attempt to identify a means of choreographing emotional expressions.

4.1.2 Generating acted expressions

The second study sought to capture video of posed expressions. In this case, two professional actors (one female, one male) were recruited through a local acting company. The actors had experience on stage, screen, and in particular in role play acting for clients. Both actors were given a full brief of the project prior to their participation, and were involved in a full day of filming. The fee for their involvement was £300 in total.

4.1.2.1 Recording of acted expressions

The study of acted expressions took place in the HIVE laboratory at the University of Abertay Dundee in March 2008. Both actors were asked to sit facing a large projector screen and a mini DV camcorder. A series of emotional sequences were established based on two factors; emotion (happiness, sadness, anger, fear, disgust, surprise, and neutral), and emotional intensity (mild, moderate, and strong). Each emotional sequence consisted of three stages; for example, happiness (strong) to sadness (mild) to anger (moderate). Two methods of directing the actors were employed. The first method used was posing emotional expressions to the camera without providing the actors with an external stimulus. Ninety 'poses' - each one a three stage emotional sequence - were used. The actors each sat in front of the camera and projector screens. They could not see each other, as they were separated by a barrier. Details of the posed sequences were displayed on both projector screens simultaneously, so that the actors knew which emotions and emotional intensities to act out. All ninety of these posed sequences are detailed in Appendix VIII, with videos from the captured expressions. The second method was role play based. Fourteen scenarios were proposed, each one containing a three-stage emotional sequence which would be experienced by one of the actors (the protagonist) in the scene. The second actor would function as a stimulus for the emotional reactions of the protagonist. All fourteen role play scenarios were rehearsed and then filmed, with both actors taking turns to play the role of the protagonist. The fourteen role play scenarios and files derived from the captured footage are

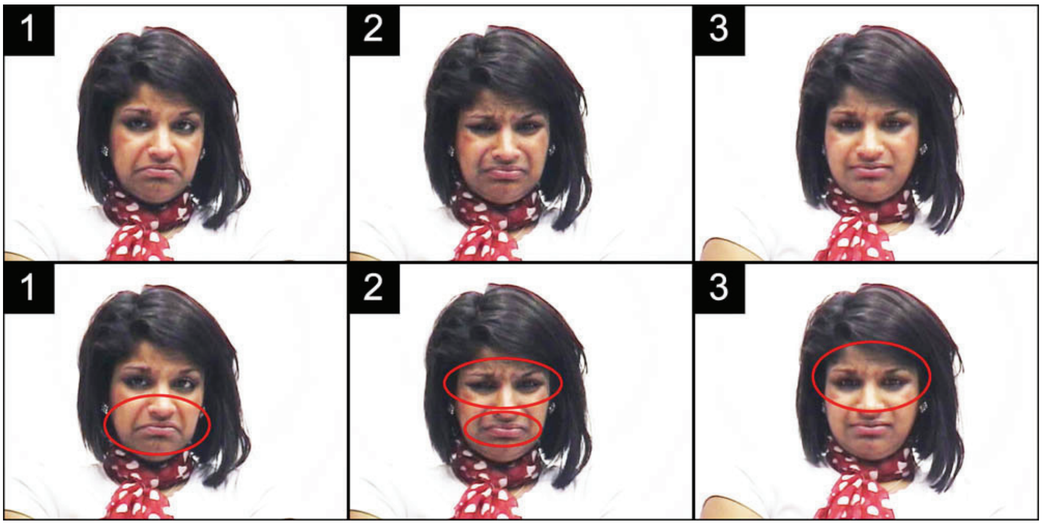


Figure 4.8: Three frames depicting an actress expressing sadness. As shown in the lower row of frames, the lower face appears to intensify prior to the expression of sadness in the eyes and brows. In the offset, the lower face seems to dissipate more quickly than the upper face.

detailed in Appendix VIII. This study was initially reported in Sloan et al. (2008).

4.1.2.2 Observational study of acted expressions

As with the observational study of naturalistic expressions, the practitioner-researcher set out to study the acted expressions using sketching as an analytical tool. The goal was the same – to reveal aspects of facial expression movement which could influence the development of the EEC concept. The practitioner-researcher made use of the full range of posed expressions and role play videos. Many of the spatio-temporal elements identified in the previous study were also highlighted in this study. For instance, analysis of the posed expressions – such as the expression of sadness shown in Figure 4.8 – again revealed that the sequence and timing of regional movement was a key concept in the development of EEC. In this example, the lower face was shown to express a frown, before the eyes and

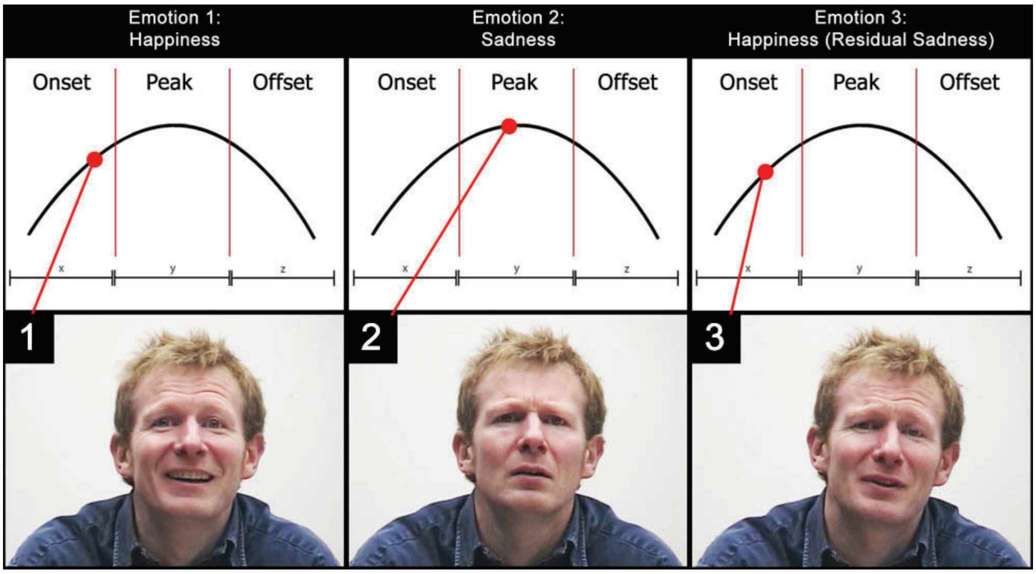


Figure 4.9: An actor expressing three emotions (happiness, sadness, happiness) sequentially. In the onset of the second expression of happiness, an element of sadness is still apparent in the furrowed upper brow, suggesting residual emotion.

brows expressed sorrow at the peak of the emotion. Furthermore, the offset of this expression (back towards a neutral expression) also appeared to contain sequential movement, with the lower frown fading before the upper expression dissipated. Sketching of the acted expressions reinforced the idea that EEC could be defined by the sequence, timing, duration, and severity of facial movement. One of the most interesting findings that came about as a result of observational sketching of posed expressions was the idea that variation in emotional experience could affect the way the specific expressions move. For instance, Figure 4.9 shows a performance of happiness, through sadness, and back to happiness again. In this example, the actor's posed expression of happiness had a different appearance on either side of the expression of sadness. In effect, it appeared as though the feeling of sadness had modulated how a subsequent feeling of happiness was expressed, to the point that a degree of 'residual emotion' (remnants of the sadness expression) was apparent in the upper face even after the

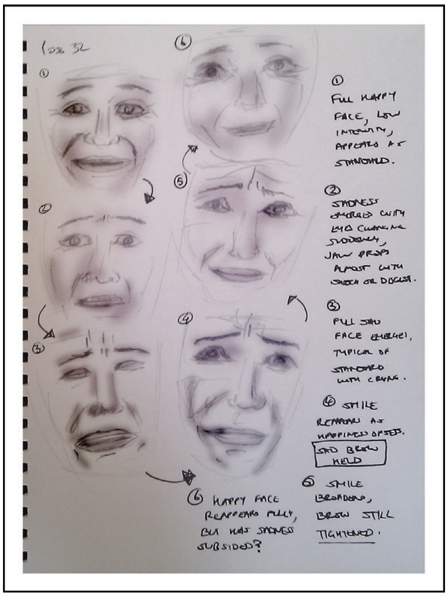


Figure 4.10: Excerpt from acted expression observation sketchbook, depicting the appearance of residual emotion from sadness to happiness.

emergence of the smile. Analytical sketching of acted expression transitions (Figure 4.10) highlighted residual emotion as potential component of EEC. In addition to the idea that EEC could be defined by the sequence, timing, duration, and severity of movement, the study of acted expressions underlined the importance of emotional context; in other words, the effect of other feelings and thoughts on the expression of a particular emotion.

4.1.3 The development of emotional expression choreography

From these initial studies of expressions of emotion, the concept of EEC began to take shape. Studies of naturalistic and acted expressions provided inspiration in terms of identifying spatio-temporal aspects which could be explored through performative research. With the naturalistic expressions, it became clear that the appearance of emotional emblems could be configured over time, and that timing could be dependent on the specific emotion (happiness, sadness etc.) or on the person's cognitive process (in line with the work of Scherer, 1999). These expressions of emotion were all in response to observed visual stimuli, so there was a bias towards reaction in and around the eyes prior to movement elsewhere in the face. It was apparent that many expressions could appear very quickly, and that the full facial expression may emerge simultaneously in some cases. Evidence of cognitive appraisal was identified, such as masking of emotion (particularly so with anger, which was well disguised by participants who claimed to feel the emotion). Overall, the naturalistic expressions offered an insight into the noise inherent in dynamic genuine expressions, with many movements – for example biting the lip or sliding the jaw during sadness – breaking up the clarity of the expressions. The acted expressions, on the other hand, were more straightforward, and the posed emotions appeared intense and exaggerated. Clarity was enhanced by the actors, even though the actors employed non-emotional expressions (such as eye rolling) as part of their expressions of emotion. Some masking was used in these expressions, but overall the actors aimed to express uninhibited emotions. In consequence, the naturalistic expressions could be held up against the literature on emotional psychology discussed in Chapter 2 – these expressions were largely the result of instinctive reactions and were displayed subconsciously, but in some instances participants had the time to cognitively appraise and manipulate the appearance of their expressions. A subsequent experiment designed to assess observer identification of these expressions (see Appendix VII) demonstrated that emotions can be difficult to identify when they are genuine, which is in line with Plutchik's (1994) insistence that emotions do not occur in pure, basic states (i.e. naturalistic emotional expressions are more subtle, varied, or complex than the distinct expressions often discussed). Conversely, the acted expressions were typical of the universal expression appearances described by Ekman and Friesen (1975).

On the whole, the purpose of these exercises in expression recording and analysis was to provide the practitioner-researcher with inspiration in terms of identifying a means to choreograph dynamic expressions using artistic production methods. The earlier review of animation literature revealed a trend in terms of sequential movement within character facial movements, roughly in line with the traditional principles of Overlapping and Secondary Action (Thomas and Johnston, 1981). This idea was reinforced by the studies of naturalistic and acted expressions, and the sequence and timing of facial regions within expressions of emotion was revealed as a key temporal characteristic. Drawing from acted expressions of emotional transitions, the practitioner-researcher picked up on the presence of residual emotion; the idea that elements of the previous felt emotion would still be present in the face when the next emotion was being experienced and expressed. These findings informed the refinement of the EEC concept so that it roughly equated to the sequence, timing, duration, and severity of movement of the three facial regions as described by Ekman and Friesen (1975); the brows, eyes, and lower face. In addition, emotional context was confirmed as a component of EEC, so that it was essential to define what the first and second emotions were in each animation. For example, in the context of an animation from sadness to happiness, the brow shape associated with sadness could remain as a residual expression in a shift towards happiness, where the smile appears first. In this instance, the lower face would effectively lead the change in expression from happiness to sadness.

On the back of these studies, the following proposal was established as a means to choreograph expression animation, and to inform the development of a facial animation rig[1] capable of handling variations in EEC:

- Expressions may be choreographed in terms of the distinct movement and appearance of the three traditional facial regions; the brows and forehead, the eyes and lids, and the lower face. As such, the rig must be capable of animating these features independently in order to sequence the animation of facial regions.
- Expressions may be choreographed in terms of severity of movement of the three regions. As such, the rig must be capable of animating variation in severity, including both subtle and extreme movements.
- Expressions may be choreographed in terms of the duration of held features, and of the overlap between features associated with disparate emotions. As such, the rig must be capable of displaying multiple expressive elements simultaneously for extended durations without risking the stability of the rig and/or mesh.

[1] A character rig in 3D animation typically refers to the 3D geometry of the character, the skeletal system and morph targets which drive vertex animation, and the associated controls used by the animator. See 2.3.2 for more details on computer animation techniques.

- An effective choreography of an expression animation may be dependent on the emotional context, in terms of the first and second expressed emotion. As such, the rig must be capable of displaying distinct emotions while also allowing for mixed emotional displays.

With a basic framework of facial expression choreography in place, the next step in the performative study was to produce an appropriate character rig which could be used in all studies of emotional expression animation.

4.2 Development of the emotional avatars facial animation rig

After the initial studies of dynamic expressions, the practitioner-researcher began preparing for animation. In order to produce original facial animation, an appropriate 3D character rig was required. The rig needed to have a focus on facial movement (adhering to the points established in the previous section), and had to be capable of reproducing the distinct movements that can be performed in nature. Facial anatomy publications and websites (Ekman and Friesen, 1975; Faigin, 1990; Hager, 2003) as well as the original studies of naturalistic and acted expressions proved invaluable resources in the development of the rig. Additionally, the practitioner-researcher's own observational sketches and life drawing informed the production process. The development of complex facial animation setups is covered in related animation literature (Kalwick, 2006; Osipa, 2007), as well as in computer animation research (discussed in Chapter 2). Numerous setups were considered for the project, including free character rigs such as the 'Andy Rig' (CreativeCrash.com, 2010) and the Facial Animation Toolset developed at Filmakademie Baden-Würtenmerg (Institute of Animation, Visual Effects and Digital Postproduction, 2006). After consideration of possible avenues, it was clear that the most appropriate solution was to develop a completely new rig, so that the character would be flexible and adaptable enough to meet the needs of the project. Two potential methods reviewed in Chapter 2 were available; the development of a joint-driven facial rig (where 'bones' would be positioned within the face and rotated to manipulate nearby vertices) and the development of a blend shape driven facial rig (where each individual facial movement would be sculpted by the artist). The blend shape method was chosen based on the project's requirement for nuanced facial movements, and the fact that the character appearance would not be considered crucial to the animation experiments or subsequent studies. Osipa's (2007) procedure for developing a 3D blend shape-based facial rig was chosen to aid development. The development and refinement of the final facial animation setup is discussed in detail in Appendix IX. The rig was tested to ensure that it was capable of imitating natural movement. The primary facial movements and shapes demonstrated in Ekman and Friesen (1975) were replicated; partly as a means of testing rig stability, and partly to create a guide for student animators who would later use the facial animation rig. A condensed version of this test is included in Appendix IX. Figure 4.11 shows examples of imitated expressions, based on footage of participants and actors from earlier studies. As a result of these tests, minor changes were made to control values in order to refine the responsiveness and

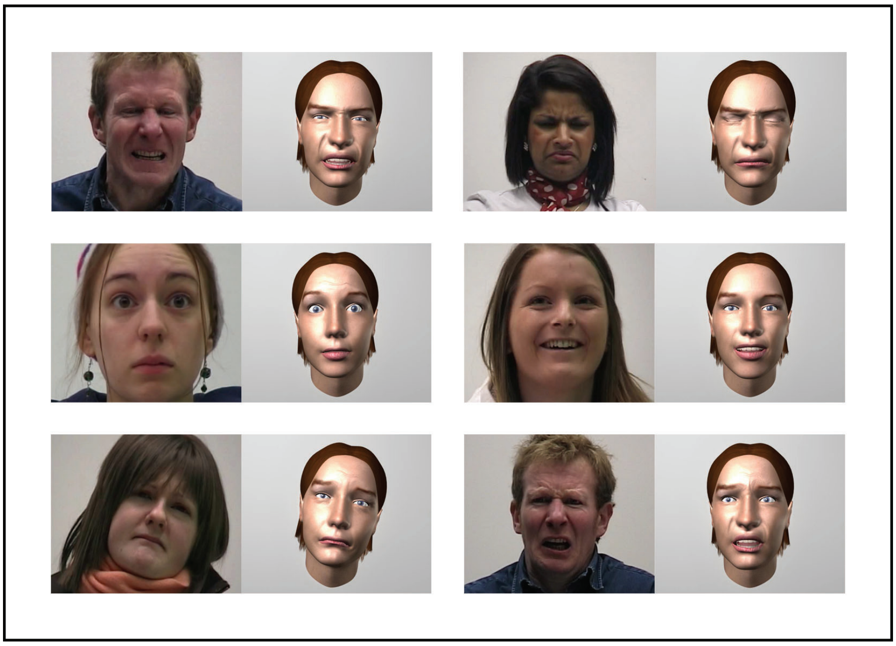


Figure 4.11: Imitation of natural and acted expressions of emotion using the final Emotional Avatars rig.

accuracy of the rig. The final facial animation rig was then set for a performative investigation into the concept of EEC.

4.3 Preliminary animation studies: exploring the potential of emotional expression choreography

With new reference material and a fully functioning facial rig ready for animation, a series of exploratory studies were planned in order to experiment with the concept of EEC following the performative methodology. Nuanced facial expression was clearly identified as a complex issue, and a number of potential considerations for EEC were highlighted as a result of the earlier studies; namely, the severity of movement, the duration of movement, and the sequence and timing of regional movements. The first stage of this animation study concerned the animation of the universal expressions at varying degrees of expressional severity. The goal of this study was to determine whether practice-based experimentation with the intensity of emotional experience could reveal how expression animations may be choreographed in terms of the severity of movement. The second study sought to explore the potential effect of manipulation of duration in animation production, specifically as regards the length of time allocated to emotional onsets. The final study focussed on the regional sequencing of three of the six expressions (sadness, fear, and disgust). In this case, the eyes, brows, and lower face regions were animated sequentially in order to determine how effective manipulation of sequence and timing could be as a core facet of EEC. The key details and findings of these three studies are covered in Appendix X. The animations produced as a result of these studies are included in Appendix XI.

4.3.1 The development of a final framework for emotional expression choreography

In these early explorations of EEC, the potential of a range of variables were examined through studio practice. The severity of regional movement in relation to the intensity of the emotional experience proved to be an appealing area for further examination. However, the severity of movement could broadly be seen to correlate with emotional intensity in an almost linear fashion (see Sloan, Cook and Robinson, 2009). A similar conclusion emerged from manipulation of expression duration through practice-based research, with the duration of the emotional onsets and peak expressions relating to intensity but also to potential context. The most interesting findings related to practice-based experimentation with the sequence of facial regions.

Experimentation with choreographing the three regions of the face revealed a great deal of complexity; not only did the use of three regions result in an unfeasibly large number of combinations when based on the sequence and timing of those regions – thirteen per emotional expression – but the subtlety in movement made it difficult to ascertain the believability or potential context of those choreographies. In short, it was plain that the number of regions had to be reduced in order to simplify future artistic study, as well as subsequent quantitative and qualitative studies which would be based on the animation produced through performative research. The decision was therefore made to refine the EEC concept so that it was founded on the configuration of just two facial regions – the upper and lower face. While Ekman and Friesen (1975) made a compelling case for independent treatment of the three regions, much of the animation literature (Kalwick, 2006; Osipa, 2007) focussed on the role of two regions – the eyes (including brows) and the mouth. Accordingly, a two-region framework for EEC based on the sequence and timing of those regions was proposed (see Figure 4.12).

In this final proposal of EEC, five combinations (or choreographies) of movement would be applied to each expression during animation production. These five choreographies are detailed in Table 4.1. The choreographies would be based on the sequence (Seq.) and timing (Tim.) of the upper and lower face regions. With two face regions, three sequences were possible; simultaneous movement of both regions (labelled as Seq.1), upper face moves before the lower face (labelled as Seq.2), and lower face moves before the upper face (labelled as Seq.3). In addition, the animation principle of Timing was also taken into account so that Overlapping and Secondary

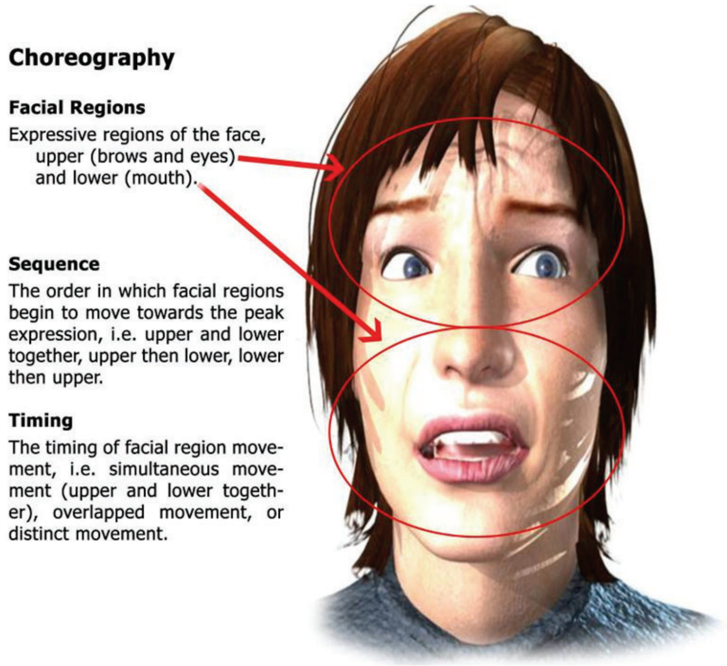
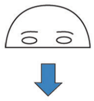
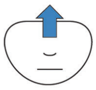
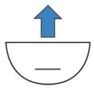


Figure 4.12: The final proposal for emotional expression choreography.

Action were applied to both the upper and lower face leading variations; Overlapping Action dictated that the movement of regions would overlap (labelled as Tim.A) while Secondary Action dictated that the movement of the regions would be distinct (labelled as Tim.B). The introduction of explicit variation in timing resulted from the practice-based findings of the preliminary animation studies, where the effect of sequence was observed to be manipulated through the animator's choice in Timing, Overlapping Action, and Secondary Action. By controlling for timing as part of the EEC framework, it would therefore be possible to determine whether the use of Overlapping Action or Secondary Action could affect the nature of the expressed emotion.

The five choreographies described in Table 4.1 were brought forward into the final two studies of emotional expression animation in a bid to determine whether variation in EEC could affect the clarity, authenticity, and

Table 4.1: The final five choreographies used to animate emotional expressions in the latter performative studies.

Choreography			
Seq.	**Tim.**	**Tim.**	**Description**
1	**-**		Simultaneous movement of both the upper and lower face regions
2	**A**		Upper face leads the lower face with overlapped timing
2	**B**		Upper face leads the lower face with distinct timing
3	**A**		Lower face leads the upper face with overlapped timing
3	**B**		Lower face leads the upper face with distinct timing

context of expressions. For the remainder of the thesis, the five choreographies will be referred to in the Seq. and Tim. format; for instance, Seq.1 for simultaneous movement of facial regions, or Seq.2 Tim.A for upper face leading the lower face with overlapped timing.

4.4 Animation study 1: the animation of choreographed emotional expressions

Animation study 1 was designed to investigate the artistic application of the final framework of EEC as applied to the universal expressions. This meant that five choreographies (simultaneous movement, upper face leading with overlapped timing, upper face leading with distinct timing, lower face leading with overlapped timing, and lower face leading with distinct timing) were used to animate six expressions (happiness, sadness, anger, fear, disgust, and surprise).

4.4.1 Research questions

As discussed in Chapter 3, the purpose of the performative phase of facial animation research was to determine whether animation practice could reveal a means of choreographing emotional facial expressions in order to produce clear and authentic animation. Primarily, this phase of research could be seen as a means of generating key-framed facial animation to be used as stimuli in future experiments. However, by developing the animations using the procedure for emotional expression animation and analysis (3.6.3.3), a range of practice-based research questions could be proposed:

I. Are certain choreographies more artistically intuitive to apply to emotion expression animation than others?
II. Do certain choreographies result in emotional expression animation that could be perceived as more clear and authentic than other choreographies and, as a result, can predictions be made regarding the clarity and authenticity of each EEC?
III. When applied in practice to various emotional expression animations, is it possible to reveal potential emotional, situational, or narrative contexts for EECs?

It was therefore predicted that the practitioner-researcher would find certain EECs to be more or less intuitive for each emotional expression. In all cases, the goal of the practitioner-research was to produce genuine, pure, and clear expressions of happiness, sadness, anger, fear, disgust, and surprise. An EEC would only be considered to be artistically intuitive or easy to use in practice if it aided in achieving this goal. Furthermore, it was predicted that the practitioner-researcher would be able to make informed predictions regarding the potential clarity and authenticity of emotional expression choreographies, framing his observations with an understanding of both Ekman's (1992) basic emotion characteristics and the principles of animation. Finally, it was predicted that the application of choreography in practice would generate insight into a potential context for each EEC.

4.4.2 Study design

The performative methodology discussed in Chapter 3 was applied to this study of EEC. As such, arts-based materials, journal entries, and structured reflections were produced as part of the methodological procedure. The arts-materials and journal were used to record the process and thoughts of the practitioner-researcher in action. Following the development of facial animation, periods of structured reflection were conducted in order to clarify the practitioner-researcher's encounters with choreography animation and to evaluate the results of creative practice. The journal for Animation Study 1 is included in Appendix XII. All of the final animations produced as a consequence of this study are provided as Appendix XIII. Arts-based materials, journal notes, final animations, and evaluations were compiled in the multimedia matrix (Appendix V), which served as the primary analytical tool in this study.

4.4.3 Results

In the following sections, the results of the study are summarized based on artistic-reflective data generated in the arts-materials, journal, structured reflection documents, and final animations. Note that these results are exclusively the observations and conclusions of the practitioner-researcher, substantiated by the documents and animations in the associated appendices and framed by visual arts research epistemology discussed in Chapter 3. The aim of this results section is to present these highly subjective observations, drawing attention to findings which relate to the three core themes of the study; artistic intuition and practicality, potential expression reliability, and context. It is recommended that the reader open the multimedia matrix (Appendix V) and browse to the relevant expressions, in order to view final animations for each EEC while reading this results section.

4.4.3.1 Happiness

For happiness, the practitioner-researcher observed that choreographies which led with the lower face were more intuitive to use in animation than alternative choreographies. Both timing variations for this sequence – overlapped (Seq.3 Tim.A) and distinct (Seq.3 Tim.B) – were found to be intuitive choreographies for happiness. Of these, the latter was the most intuitive to act out in the planning stages (using a mirror), while the former was a more natural animation choice and implied appropriate use of Overlapping Action. In comparison, choreographies which started with the upper face were observed as counter-intuitive, at least for animating pure happiness. When the upper face moved first for happiness, the planning stage of the animation inquiry cycle revealed a more complex or mixed emotion. Simultaneous movement of upper and lower face regions – while more intuitive than initial upper face movement – was found to be somewhat counterintuitive in an anatomical sense (i.e. the most intuitive movement of the upper face was as an Overlapping or Secondary Action resulting from upward movement from the lower face). Overall, leading with the lower face emerged as the most artistically intuitive choreography when framed by the animation principles arm of the analytical procedure.

The next major issue investigated through practice was the potential clarity and authenticity of the choreographed emotional expressions. In this respect, all choreographies were generally regarded as reliable, although – as predicted by the literature (Messinger et al., 2001) – the practitioner-researcher observed that happiness appeared more believable when the lower face led the facial movement. Of these two choreographies, overlapped timing (Seq.3 Tim.A) was observed to be an authentic quick smile – complete with Quick Onset and an apparent Unbidden Occurrence – while distinct timing (Seq.3 Tim.B) appeared as a more complex yet equally authentic animation. Despite being counterintuitive and relatively difficult to apply in practice, the choreographies that led with the upper face showed potential as reliable animations of happiness – at least to an extent. It was noted that context could dictate the potential reliability of these choreographies, particularly as regards the perceived authenticity of resulting animations. Finally, simultaneous movement was observed as being a somewhat reliable choreography for producing authentic and clear happy animation, but again context played a role. It was observed by the practitioner-researcher that the simultaneous movement of the facial regions warranted a very specific, ‘instant happy reaction’, and that out of context the perceived authenticity could wane.

As regards context, genuine felt happiness was most apparent in lower face leading choreographies, with Seq.3 Tim.A appropriate as a sudden but authentic feeling of happiness, fitting with the ideas of Quick Onset and Automatic Appraisal, while Seq.3 Tim.B contained a higher degree of cognitive appraisal but was deemed equally sincere. Simultaneous movement met most of Ekman’s criteria and as such was potentially authentic as an emotional response, but the instantaneous movement across the face hinted that it could be a deliberate pose rather than the result of an Unbidden Occurrence, and as such could be perceived as insincere. Leading with the upper face altered the context to include more apparent cognitive appraisal and emotional control, as well as the appearance of complex emotion – in particular the indication of confusion, suspicion, contempt, or insincerity.

Table 4.2 highlights the subjective conclusions assigned to each EEC for each factor, based on findings highlighted by structured reflection. As regards predictions for which choreographies would appear most authentic when shown to observers, Seq.3 Tim.A was predicted to be the most perceptually authentic choreography for pure, unbidden happiness, with Seq.3 Tim.B being the next most authentic animation. It was predicted that both timing variations for Seq.2 would result in less authentic animation of pure happiness.

Table 4.2: An overview of the practitioner-researcher's observations for animations of happiness.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Somewhat	Clear	Potentially Authentic	Happy response, although potentially insincere or uncanny.
Seq.2 Tim.A	No	Mixed	Inauthentic / Masked	Complex happiness. Initial uncertainty or mixed with confusion, suspicion, disgust or contempt.
Seq.2 Tim.B	No	Mixed	Inauthentic / Masked	Complex happiness. Mixed emotion with initial disgust, contempt, confusion, or suspicion.
Seq.3 Tim.A	Yes	Clear	Authentic	Genuine, heart-felt happiness.
Seq.3 Tim.B	Yes	Clear	Authentic	Slower development of genuine happiness. More apparent thought process

4.4.3.2 Sadness

Animations of sadness were most intuitive to animate when the upper face was involved in the initial movement, but also when the lower face led with overlapped timing. Seq.2 Tim.A was the most intuitive to animate following the principles of animation, with a clear use of Overlapping Action, and also Anticipation in that the movement of the eyes set up the Exaggeration of the downturned lips. Seq.2 Tim.B required a more thoughtful application of Timing to ensure that the lower face peaked at an appropriate time, which proved a little more difficult to generate in the studio. The alternate sequence of Seq.3 Tim.A unexpectedly proved to be quite intuitive to animate. With distinct timing this sequence was counterintuitive, as the Staging of the emotion was hampered by the expressionless upper face. The lack of scope for experimentation with Timing in the simultaneous animation resulted in Seq.1 being a counterintuitive choreography.

Evaluating the animations from the perspective of emotional psychology, firstly it was clear from the literature that sadness is an emotion with a distinctly extended onset and duration – particularly when compared to the other universal expressions. This impacted on the role of Automatic Appraisal, as the choreographies which favoured an extended, cognitive appraisal appeared more authentic as sadness; particularly Seq.2 Tim.A, Seq.2 Tim.B, and Seq.3 Tim.A. Where Seq.3 Tim.B broke this trend was in the lack of an Unbidden Occurrence, as this choreography looked more like a planned or deliberately triggered emotion. While simultaneous movement contained a Quick Onset and evidence of an Unbidden Occurrence, the lack of control dampened the authenticity of an emotion which may typically be held back, at least initially. In context, the lack of subtlety displayed in the simultaneous choreography led to the conclusion that two potential contexts may be appropriate; that the emotion was deliberately staged, or that the Antecedent Event was particularly severe and sudden (as in grave news delivered in an instant). By having the upper face lead, contexts where the emotion was genuine could be more readily applied; the evident thought process followed by a pang of sadness across the face in Seq.2 Tim.A indicated that the emotional trigger was external and the emotion genuine, while a higher degree of appraisal and emotional control was shown in Seq.2 Tim.B. The thought process shown in the latter choreography could also

Table 4.3: An overview of the practitioner-researcher's observations for animations of sadness.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	No	Clear	Potentially Authentic	Too quick a development for the emotion, could be staged. Potentially authentic in the context of unexpected bad news.
Seq.2 Tim.A	Yes	Clear	Highly Authentic / Sincere	Genuine and sudden feeling of sadness. Thinking before emotion intensifies.
Seq.2 Tim.B	Yes	Clear	Authentic	Genuine sadness, attempt made to control emotion. Internal stimulus event.
Seq.3 Tim.A	Yes	Clear	Potentially Authentic	Masking in the upper face. Attempt to control sadness, external stimulus event.
Seq.3 Tim.B	No	Confusable	Inauthentic / Insincere	A posed, childish sadness. Insincere.

suggest that the Antecedent Event could have been internally generated, such as a memory triggering a feeling of sadness. Masking was evident in the animation of sadness using Seq.3 Tim.A, with the upper expression held back momentarily. When distinct timing was used with Seq.3, however, the context became very clearly one of a faked emotion, almost childlike and pleading in nature. Table 4.3 shows the subjective ratings for each EEC. Seq.2 Tim.A was predicted to be the most authentic choreography, followed by Seq.2 Tim.B, then Seq. 3 Tim.A and Seq.1. The remaining choreography – Seq.3 Tim.B – stood out as the only inauthentic animation. Across the board the animations were clearly representative of sadness, although Seq.3 Tim.B could be more confusable with other expressions.

4.4.3.3 Anger

In terms of animating anger following the principles of animation, simultaneous movement and upper face leading proved most intuitive. Seq.1

was straightforward to animate, and particularly allowed for Exaggeration to be applied with a broad, extreme change in expression. This in turn made the choreography appear more comical, in line with the cartoon tradition in animation. On the other hand, leading with the upper face was more intuitive, as Overlapping Action and Secondary Action enhanced the thought process and resulting emotional reaction. As with other emotions, leading with the lower face undermined good Staging of anger, which was largely dependent on the lowering of the brow. The role of the brow in making a clear expression of anger was backed up by the emotional psychology literature, which underlined this feature as the key universal signal in anger, while the bearing of the teeth could be more closely associated with an intense feeling of rage. The Antecedent Event for a feeling of anger was perhaps most obvious when the eyes and brows moved initially, showing an Automatic Appraisal of an observed threat or obstacle. This all led to the practitioner-researcher concluding that upper face choreographies were both clear and authentic as expressions of anger, while leading with the lower face proved more problematic. The problem with lower face leading was the suggestion of mixed emotional signals (in particular an element of disgust) which broke down the clarity of the animations. Evaluation from the perspective of the principles of animation and basic emotion characteristics resulted in proposed contexts across all choreographies. The sudden and complete movement of Seq.1 indicated that the Antecedent Event was unexpected and highly threatening. In any other context this EEC could look comical or overstated. Seq.2 Tim.A and Seq.2 Tim.B could fit with contexts where the threat or obstacle was observed, considered, and the emotional response developed

Table 4.4: An overview of the practitioner-researcher's observations for animations of anger.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Presented with a sudden and unwelcome threat.
Seq.2 Tim.A	Yes	Clear	Highly Authentic	Observation of threat leading to an increasing feeling of anger.
Seq.2 Tim.B	Yes	Clear	Authentic	More apparent thought process, potentially confusion leading to a feeling of anger.
Seq.3 Tim.A	No	Unclear	Inauthentic	Element of disgust or contempt, followed by anger. A mixed emotion response to a disgusting stimulus.
Seq.3 Tim.B	No	Unclear	Highly Inauthentic	Disgust, into anger. Appearance of rage without action in the eyes could indicate that the emotion is displayed but not felt, as if to threaten while also experiencing fear.

over time. The latter EEC may also be suitable to a context where the trigger leads to an initial feeling of confusion. In contrast, Seq.3 Tim.A and Seq.3 Tim.B could only be suitable to contexts where anger was simultaneously experienced alongside other emotions and thought processes, specifically disgust, contempt, or fear.

The subjective ratings assigned to each EEC are shown in Table 4.4. As regards predictions for which EECs would appear most authentic, Seq.2 Tim.A and Tim.B were predicted to be the most believable and clear expressions of genuine anger, while Seq.3 Tim.A and Tim.B were predicted to be both inauthentic and confusable with other emotions.

4.4.3.4 Fear

Experimentation with Timing between an initial upper face and subsequent lower face pose revealed that Seq.2 Tim.A was the most intuitive

EEC for an animation of fear. While the Secondary Action of the distinct timing variant created an effective fear expression, the Overlapping Action of Seq.2 Tim.A appeared more intuitive and resulted in an expression which was more clearly staged. Once again, the lack of either Overlapping Action or Secondary Action in simultaneous movement made Seq.1 a little less intuitive, although the Staging of this EEC was strong. As with several other expression animations, choreographies which led with the lower face were counterintuitive to work with, and seriously degraded the Staging of the expression. When evaluated using Ekman's characteristics, variation in the timing of upper and lower features could be understood from an evolutionary psychology perspective. For instance, an initially frozen upper face in Seq.3 Tim.A could be perceived as horror (Ekman and Friesen, 1975), while the opening of the mouth could demonstrate a sharp intake of breath while fear is masked in the upper face. Generally, though, it was clear that there ought to be action in the upper face from the outset. Primarily this could be explained by the Antecedent Event of fear, an observed threat triggering a widening of the eyes in order to take in more information. In this sense, an expression of genuine fear should lead with upper face movement, as the stimulus event is Automatically Appraised. Contextually, the Quick Onset of Seq.1 suggested that, not only was the feeling of fear an Unbidden Occurrence, but also that the stimulus emerged suddenly and perhaps violently, leading to a fear-surprise reaction. Seq.2 Tim.A, and to a lesser extent Seq.2 Tim.B, presented animations which were less context dependent. The latter could be likened to an expression of worry, which in turn may indicate that the Antecedent Event was less immediate. No conceivable context could be extracted for Seq.3

Table 4.5: An overview of the practitioner-researcher's observations for animations of fear.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Fear reaction, element of shock or surprise, clearly unbidden occurrence.
Seq.2 Tim.A	Yes	Clear	Authentic	Context independent. Threat observed, emotion intensifies after initial reaction.
Seq.2 Tim.B	Yes	Clear	Potentially Authentic	Apprehensive. A slower development of full fear from an initial sense of worry. The perceived threat likely intensifies over time.
Seq.3 Tim.A	No	Confusable	Inauthentic	Could be perceived as disgust initially – potentially effective in a context where disgust precedes fear.
Seq.3 Tim.B	No	Confusable	Highly Inauthentic	Mechanical and unnatural development, unlikely to be applicable to a suitable fear context.

Tim.B through consideration of either the principles of animation of Ekman's basic emotion characteristics. Table 4.5 details the practitioner-researcher's predictions for the various choreographed animations of fear.

4.4.3.5 Disgust

Animation of disgust expressions presented a unique finding for the study, in that all five choreographies were considered intuitive in different contexts. Leading with the lower face was marginally more intuitive to work with, as the Staging of the emotion was easier to achieve (drawing attention to the sneer). In a comic sense, it made sense to strongly emphasise the sneer at the expense of having the eyes react either as an Overlapping or Secondary Action. Conversely, leading with the upper face appeared intuitive, but more careful consideration of Staging was required so as to avoid

Table 4.6: An overview of the practitioner-researcher's observations for animations of disgust.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Strong and unexpected feeling of disgust, fully automatic appraisal, a surprise-disgust mix.
Seq.2 Tim.A	Yes	Confusable	Potentially Authentic	Higher degree of extended appraisal, applicable in contexts where the stimulus can be considered and the emotion regulated.
Seq.2 Tim.B	Yes	Unclear / Confusable	Potentially Authentic	Contempt-disgust, observation of a stimulus which triggers a mild feeling of disgust initially or feelings of anger.
Seq.3 Tim.A	Yes	Clear	Authentic	Unbidden occurrence and automatic appraisal, limited control over the disgust reaction, most broadly applicable choreography.
Seq.3 Tim.B	Yes	Clear	Authentic	Extended appraisal variant of the above choreography, unable to mask initial disgust feeling, emotion intensifies after appraisal.

confusion over the nature of the emotion being expressed. Anticipation was applied here, by using the lowering of the brow and squinting of the eyes to point to the more dramatic (and symbolic) sneer of disgust. Simultaneous movement required close attention in terms of Timing, to ensure that the expression was clearly shown as disgust and not shock or anger. In terms of the psychological background of these choreographies, it could be determined that all were potentially authentic expressions, but not necessarily as pure expressions of disgust. The Antecedent Event and the Unbidden Occurrence of the emotion would suggest that the sneer ought to be crucial to an expression of pure disgust, as the disgust stimulus (or poison) must be rejected. However, disgust may not be expressed in its pure state, and could for instance incorporate other emotions, such as contempt. When the emotion is mixed, choreographies leading with the upper face could also be seen as authentic. The swing from lower face to upper face choreographies of disgust could therefore be seen as a shift from fully Automatic Appraisal to an extended, cognitive appraisal. A consequence of this was the potential breakdown of the clarity of the expression when the upper face led, as the animation could be confused with anger or contempt. Seq.1, on the other hand, would appear to represent a pure and sudden feeling of disgust, perhaps with an element of surprise. Table 4.6 details the practitioner-researcher's predictions for disgust choreographies.

4.4.3.6 Surprise

The final expression in the study was of surprise. Initially, simultaneous movement seemed to be an appropriate choice, due to the Quick Onset of the emotion. In practice the lack of Overlapping Action was somewhat counterintuitive, resulting in a rather lifeless animation at first. A good solution was to introduce Anticipation through head motion, and also through a blink (timed to match the first movement of the jaw). By shifting the upper face slightly ahead of the mouth in Seq.2 Tim.A, not only did the Overlapping Action create a smooth flow down the face, but the Anticipation was also accentuated. The reverse movement of Seq.3 Tim.A was slightly less intuitive, in that the Staging of surprise was not as effective, but overall these three choreographies proved to work aesthetically. Problems were encountered with the distinct timing choreographies; both Seq.2 Tim.B and Seq.3 Tim.B suffered in terms of Staging and a breakdown in Overlapping Action. It was difficult to introduce suitable Timing between the key poses, and ultimately the animations looked disjointed and unclear.

Evaluation using Ekman's basic emotion characteristics revealed similar problems with distinct timing. As surprise is clearly a fleeting emotion, the lack of a Quick Onset severely disrupted the believability of the animations, with Seq.3 Tim.B in particular lacking the appearance of Automatic Appraisal. As a result, both Seq.2 and Seq.3 Tim.B could be less clear than the alternate choreographies, and may even be interpreted as inauthentic, faked, or dazed expressions rather than genuine surprise. The remaining choreographies – in particular Seq.2 Tim.A and Seq.1 – benefitted from the Quick Onset and Automatic Appraisal crucial to an emotion. In particular for surprise, the almost instantaneous movement in the eyes and jaw seemed more appropriate for the likely Antecedent Event, which would likely be a sudden and unexpected external stimulus. In context, then, these two choreographies would be appropriate for expressions of surprise that are largely context-free; the stimulus would be unexpected, and the reaction would be to stop and observe. Seq.2 Tim.A would perhaps be suitable to a context where curiosity was more pronounced. Seq.3 Tim.A on the other hand may be suitable to a context where the surprise was anticipated, resulting in an expression of surprise and interest. The distinct timing choreographies would be more appropriate to contexts where the surprise is not genuine or when the expression is staged. In both cases, the expression

Table 4.7: An overview of the practitioner-researcher's observations for animations of surprise.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Strong shock, truly unexpected event. Event directly affects individual.
Seq.2 Tim.A	Yes	Clear	Authentic / Sincere	Genuine surprise, less immediate but no less unexpected. Surprise at external observed event, curiosity.
Seq.2 Tim.B	No	Confusable / Unclear	Inauthentic	Dumfounded. Observation of unexpected event, unravelling more slowly.
Seq.3 Tim.A	Yes	Clear	Authentic	Surprise with anticipation. Stimulus is detected prior to observer, perhaps extended appraisal. Interest.
Seq.3 Tim.B	No	Confusable / Unclear	Inauthentic / Insincere	Faked surprise, display of surprise expression.

may be considered a sarcastic take on surprise. Table 4.7 details the final predictions for choreographed animations of surprise.

4.4.4 Discussion

Overall, the results of this study demonstrated that the concept of EEC (defined as the sequence and timing of the upper and lower face) clearly impacted on the practitioner-researcher's production and evaluation of facial animation. In terms of the artistic intuition of various choreographies, framed by the principles of animation, it was evident that simultaneous movement was largely overshadowed by animations which employed tactful use of Overlapping Action or Secondary Action. In other words, the practitioner-researcher tended to favour either upper or lower face leading (Seq.2 or Seq.3) with either overlapped timing (Tim.A, underpinned by Overlapping Action) or distinct timing (Tim.B, essentially a Secondary Action). This finding was anticipated by the animation literature (Williams, 2001). The principles of Timing, Anticipation, and Staging further emphasised the aesthetic merit of animating a flow either up or down the face, rather than adopting a simultaneous movement. This in itself represented new knowledge in the field of animation practice, addressing the current gap in the facial animation literature identified in Chapter 2. Structured reflection on animation led to a range of subjective predictions founded upon both artistic and psychological frameworks of evaluation. While the principles of animation dictated that clarity would be achieved through appropriate use of Overlapping Action, Secondary Action, and in particular the Staging of the most prominent features on the face, consideration of Ekman's basic emotion characteristics helped to establish a clear psychological basis for predicting the success of particular choreographies. For instance, reflection on animations of fear revealed that they were most authentic when the emergence of the expression appeared to result from an Antecedent Event (e.g. observation of a threat) and when the emotion seemed to be an Unbidden Occurrence, with a Quick Onset and Automatic Appraisal. Essentially, Seq.2 Tim.A – upper face leading with overlapping action – was predicted to be the most authentic animation of fear because the eyes showed a reaction to the Antecedent Event while the mouth moved shortly afterwards, enhancing the effect of an Unbidden Occurrence of emotion. As such, the study led to a range of substantiated predictions (Table 4.8). In terms of context, the wider emotional psychology literature helped the practitioner-researcher to propose a range of situational and character-orientated contexts which could be applicable to each EEC.

Table 4.8: Final subjective predictions for emotional expression animation authenticity and clarity.

Animation	Authentic	Inauthentic	Clear intended emotion	Unclear intended emotion
Happiness	Seq.3 Tim.A	Seq.2 Tim.B	Seq.1 or Seq.3 Tim.A	Seq.2 Tim.B
Sadness	Seq.2 Tim.A	Seq.3 Tim.B	Seq.2 Tim.A	Seq.3 Tim.B
Anger	Seq.2 Tim.A or Seq.2 Tim.B	Seq.3 Tim.A or Seq.3 Tim.B	Seq.2 Tim.A or Seq.2 Tim.B	Seq.3 Tim.B
Fear	Seq.1 or Seq.2 Tim.A	Seq.3 Tim.B	Seq.2 Tim.A	Seq.3 Tim.B
Disgust	Seq.3 Tim.A or Seq.3 Tim.B	No prediction	Seq.3 Tim.B	Seq.2 Tim.A or Seq.2 Tim.B
Surprise	Seq.1 or Seq.2 Tim.A	Seq.3 Tim.B	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B

4.5 Animation study 2: the animation of choreographed emotional expression transitions

Animation study 2 was conceived as a replication of study 1, but using emotional expression transitions rather than single emotions. The idea for this study had a basis in the earlier discovery of residual emotion when analysing acted performance. In this study, the following emotional transitions were selected for investigation; surprise into happiness, happiness into sadness, sadness into anger, anger into fear, fear into disgust, and disgust into surprise. Once again, the five levels of the final framework for emotional expression choreography were used to produce the facial animation for this study.

4.5.1 Research questions

As before, the goal of this study was to identify an artistic interpretation of EEC, this time as applied to a range of emotional expression transitions. The same research questions were posed:

I. Are certain choreographies more artistically intuitive to apply to emotion expression transition animation than others?
II. Do certain choreographies result in emotional expression transition animation that could be perceived as more clear and authentic than other choreographies, and, as a result can predictions be made regarding the clarity and authenticity of each EEC?
III. When applied in practice to various emotional expression transition animations, is it possible to reveal potential emotional, situational, or narrative contexts for EECs?

It was predicted that the practitioner-researcher would find certain choreographies to be more or less intuitive for each transition. The chance of success here was high, based on the artistic conclusions that resulted from study 1. It was anticipated that the practitioner-researcher would be able to make predictions, informed by animation principles and emotional psychology, regarding the potential perceived clarity and authenticity of transition choreographies. Finally, it was predicted that the application of choreography in practice would generate insight into the potential context of each EEC.

4.5.2 Study design

As with the previous study, the performative methodology discussed in Chapter 3 was applied to the final study of emotional expression choreography. Once more, arts-based materials, journal entries, and structured reflections were produced as part of the methodological procedure. The journal was used to record the thoughts of the practitioner-researcher in action. Following the development of facial animation that adhered to the specified framework of emotional expression choreography, periods of structured reflection were conducted in order to clarify and evaluate the findings of iterative creative practice. The journal for Animation Study 2 is included as Appendix XIV. All final animations produced as a consequence of this study are provided as Appendix XV. The multimedia matrix collates arts materials, journal entries, and final animations produced for animation study 2 (see Appendix V).

4.5.3 Results

In the following sections, the results of the study are summarized based on artistic-reflective data generated in the journal, structured reflection documents, and final animations. As with study 1, these results are based on the observations and conclusions of the practitioner-researcher, substantiated by the documents and animations in the associated appendices and framed by the visual arts research epistemology. The aim of this results section is to present these highly subjective observations, drawing attention to findings which relate to the three core themes of the study; artistic intuition and practicality, potential expression reliability, and context.

4.5.3.1 Surprise into happiness

For the transition 'surprise into happiness', Overlapping Action leading from the lower face created the most artistically intuitive animation. Not only did this enhance the Staging of the smile (as observed in the previous study when animating happiness), but also the mixed emotion of happiness and surprise. With both timing variations, Seq.3 choreographies resulted in clear representations of a shift from surprise to happiness, with Anticipation of the final Duchenne smile. Upper face leading was less intuitive, particularly with distinct timing which had poor Staging. As with most animations, the lack of either Overlapping Action or Secondary Action in simultaneous movement resulted in Seq.1 being a fairly counter-intuitive choreography to work with. In particular, there was little scope for using Exaggeration as the Timing between poses was strictly controlled. When examined using Ekman's characteristics, the Quick Onset of happiness in Seq.1 did not necessarily result in an authentic expression. The lack of complexity in the transition could be linked to Plutchik's (1994) insistence that emotions rarely exist in basic states, which would explain the unnatural movement of this EEC. It was difficult to determine what the Antecedent Event for this choreography could

Table 4.9: An overview of the practitioner-researcher's observations for animations of surprise into happiness.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	No	Clear	Inauthentic / Insincere	Insincere expression of happiness following a genuine surprise. Faking, staging, exaggeration of joy.
Seq.2 Tim.A	No	Confusable	Potentially Authentic	Genuine surprise, element of confusion or suspicion prior to the expression of happiness.
Seq.2 Tim.B	No	Confusable / Unclear	Inauthentic	Additional thought process linking surprise to happiness. Appears unnatural. Faked happiness.
Seq.3 Tim.A	Yes	Clear	Authentic	Surprise followed by genuine experience of joy, context free.
Seq.3 Tim.B	Yes	Clear	Authentic / Sincere	Greater mix of surprise and happiness, clearing a pleasant surprise. Unexpected good news.

be, and the context was therefore proposed as being a faking of one or both emotions. Complexity in the transition was apparent in Seq.2 Tim.A and Seq.2 Tim.B, with a clear thought process conveyed. The cognitive appraisal of the Antecedent Event here appeared to suggest suspicion or doubt, followed by an expression of happiness which could have been staged. As such, these choreographies were somewhat problematic; in particular the distinct timing variation, which looked unnatural. In contrast, leading with the lower face created transition animations that appeared to be genuine expressions with Automatic Appraisal of the external stimulus for happiness. Seq.3 Tim.A could be applicable in a broad range of contexts, as only the Universal Signals of happiness and surprise were displayed. Seq.3 Tim.B contained a clear mixture of the two emotions at the midpoint, lending itself to a context in which unexpected good news is delivered.

The subjective conclusions for each EEC are shown in Table 4.9. It was predicted that Seq.3 Tim.A and Seq.3 Tim.B would be the animations of surprise into happiness which would be easiest to identify. These choreographies were also predicted to be the most authentic animations of the transition. The remaining choreographies were regarded as weak in comparison. Seq.1 and Seq.2 Tim.B were particularly inauthentic, while both upper leading choreographies were predicted to be the least clear animations.

4.5.3.2 Happiness into sadness

All choreographies for happiness into sadness were at least moderately intuitive, sometimes dependent on the context of the triggering event. The Secondary Action of the sad lower face expression in Seq.2 Tim.B was particularly effective, with appropriate use of Anticipation and Exaggeration adding to the potency of both the happy and sad expressions. The Staging of the Universal Signals of happiness and sadness were most apparent in Seq.1 and Seq.2 Tim.A. The former suffered from limited key poses, while the latter had more complexity through the use of Overlapping Action, producing an authentic looking development of sadness and a clear thought process. Leading with the lower face, while intuitive, had repercussions on the Staging of the emotions. Here, the happy expression shifted from a genuine smile to a posed expression, apparent through experimentation with and observation of the Timing and flow up the face. The sincerity of the emotions was the main concern when considering Ekman's (1992) basic emotion characteristics. For the lower face leading choreographies, the Antecedent Event was observed to be an interaction with another individual, with the character displaying a fake happiness while being observed. This implied a high degree of cognitive appraisal, as the sadness emotion may have been experienced while the happy expression was still displayed. Outside of this context, Seq.3 Tim.B in particular would appear quite inauthentic and insincere, incorporating both staged sadness and staged happiness. Masking was clearly apparent in Seq.2 Tim.A and Seq.2 Tim.B. In these choreographies, however, the masking occurred at the transition, and as such could be related to the Automatic Appraisal following the Antecedent Event. Here, the face drops from the eyes down to the mouth, where a lower frown occurs as the emotion intensifies. If the expression of sadness is deliberately masked with a smile, then the appraisal is clearly extended. Overall these choreographies made for much more interesting and psychologically believable expression transitions. Seq.1, while lacking in complexity, could work in a context where the happiness was staged, or where the character exhibits emotional displays in the knowledge that they are not being observed by another party (and as such are less inclined to limit their expression of sadness). All five choreographies contained the core Universal Signals and as such were unlikely to be confused with other distinct emotions.

The practitioner-researcher's predictions for each EEC are shown in Table 4.10. It was predicted that Seq.1 and Seq.2 Tim.A would be the clearest animations of happiness and sadness, although no choreography was predicted to be unclear. Seq.2 Tim.A was regarded as the choreography which would appear most authentic, followed closely by Seq.2 Tim.B. Seq.3 Tim.B was predicted to be the least authentic animation of happiness into sadness.

Table 4.10: An overview of the practitioner-researcher's observations for animations of happiness into sadness.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Straightforward transition. Expression occurs while not being observed. Potentially too swift to be completely sincere – initial faked happiness.
Seq.2 Tim.A	Yes	Clear	Authentic	Genuine happiness, through a display of happiness, to genuine sadness. Appropriate for most conceivable contexts where this transition would occur.
Seq.2 Tim.B	Yes	Clear	Authentic	Strongly masked sadness. Credible initial happiness. Deep sadness. Good for exaggeration.
Seq.3 Tim.A	Yes	Clear	Potentially Authentic	Taking in an antecedent event which has triggered a sad response. Emotion intensifies as sadness. May be a faked smile initially.
Seq.3 Tim.B	Somewhat	Clear	Inauthentic	Faked happiness, replaced by sadness which could be genuine. Expression changes when the target of the fake smile looks away. Internal antecedent event.

4.5.3.3 Sadness into anger

Neither Seq.1 nor Seq.2 Tim.A were immediately intuitive as they both proved somewhat time consuming to animate, with iterative adjustments to Timing between small expressional changes. When the end animation was produced, however, the flow down the face in Seq.2 Tim.A clearly worked aesthetically, Staging the shift from sadness to anger effectively. In Seq.1 the transition almost seemed too straightforward, lacking in the complexity that is perhaps essential to a shift between two contrasting emotions. Other choreographies were less intuitive to animate and suffered from poor Staging. Seq.2 Tim.B appeared almost comic, and the Secondary Action of rage was detrimental to the quality of the animation. Lower face leading choreographies in particular caused problems in practice, again as a result of insufficient Staging of the core emotions. For Seq.3 Tim.B, the Secondary Action in the eyes was ineffective, making the expression difficult to read. Overall, this transition proved to be difficult to animate and to evaluate using the principles of animation, most likely because it was hard to establish a suitable context for such a dramatic emotional change.

This conclusion could be substantiated through evaluation using Ekman's basic emotion characteristics. The role of Automatic Appraisal in an animated shift from sadness to anger was hard to detect, as an element of cognitive appraisal was apparent across all choreographies. Intermediate thoughts or emotions seemed to be essential to building an authentic transition, so as not to create a jarring (and therefore insincere) expression of anger. It was also difficult to determine potential Antecedent Events which could trigger a pure anger response emerging from a feeling of sadness. Irritation was conceived as the most likely thought process to precede anger, and could be inferred in Seq.2 Tim.A and Tim.B. Simultaneous movement suffered somewhat with no variation in movement, but surprise could be the intermediate emotion in Seq.1. In this sense, Automatic Appraisal was strongest in Seq.1, but the result was a shift in expression that produced an unintended transitional emotion. When leading with the lower face, the Universal Signals of anger became less consistent, resulting in unclear

Table 4.11: An overview of the practitioner-researcher's observations for animations of sadness into anger.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Genial context. A simple, uncomplicated transition with little or no intermediate feelings. Quick onset of anger. Surprise.
Seq.2 Tim.A	Yes	Clear	Authentic / Sincere	Reaction to something said or observed. Genuine anger, cognitively appraised as the event becomes apparent.
Seq.2 Tim.B	No	Potentially Confusable	Potentially Authentic	Irritated by antecedent event, cognitive appraisal develops anger. Other thoughts or emotions apparent.
Seq.3 Tim.A	No	Confusable	Inauthentic	Other emotion experienced – disgust, contempt, worry. Cognitive appraisal, perhaps not an external antecedent event.
Seq.3 Tim.B	No	Unclear	Inauthentic	Context would require anxiety or fear as a transition emotion. Otherwise appears unnatural as a transition from sadness directly to anger.

animations. Anxiety, fear, or worry could be potential transitional emotions in these choreographies, producing specific situational contexts for Seq.3 Tim.A and, to a lesser extent, Seq.3 Tim.B (which was somewhat unnatural).

The subjective conclusions for each EEC are shown in Table 4.11. Seq.2 Tim.A was predicted to be the most clear and authentic expression of sadness into anger, as it made best use of animation principles while also making most sense psychologically. Lower face leading choreographies were seen as the least clear and authentic animations, containing elements of other emotions. Seq.3 Tim.B was the least authentic overall, as it appeared quite unnatural.

4.5.3.4 Anger into fear

Generally, building a good mix between anger and fear required iterative changes and experimentation with Timing across all choreographies. Seq.1, Seq.2 Tim.A, and Seq.3 Tim.A proved to be most intuitive. Timing was essential to the animation of simultaneous movement in particular, to ensure that both expressions appeared genuine. Overlapping Action worked well, starting with either the lower or upper face. This was particularly effective for Seq.3 Tim.A, as it meant that the upper face was held back at the start. In the previous study, this choreography was found to be problematic for an animation of fear, but when anger preceded fear in this study the end result was more clearly Staged. The trend of distinct timing choreographies being counterintuitive to animate continued for anger into fear transitions, and both of these choreographies presented a greater workload for the practitioner-researcher.

Using Ekman's basic emotion characteristics to evaluate the animations, Automatic Appraisal was the most prominent factor in determining whether animation was authentic or not. Extended appraisal in the distinct timing choreographies derailed the animations, which were intended to be of a straightforward shift in emotion based on the appropriate Antecedent Event. Automatic Appraisal was more apparent in the overlapped timing choreographies. For simultaneous movement, the complete shift in emotion indicated no control, and as such this choreography could be appropriate in any context where fear is triggered based on a clear threat to

Table 4.12: An overview of the practitioner-researcher's observations for animations of anger into fear.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Fairly context independent. Straight shift from anger to fear. Antecedent event triggers strong and immediate fear response. Character not strong willed.
Seq.2 Tim.A	Yes	Clear	Authentic	Observation of an increasing threat triggers initial anxiety. Anger held on to briefly.
Seq.2 Tim.B	No	Clear	Inauthentic	Disbelief. Dazed fear, or masked fear.
Seq.3 Tim.A	Yes	Clear	Potentially Authentic	Fairly generic. Build up of dread in response to an antecedent event.
Seq.3 Tim.B	No	Potentially Confusing	Inauthentic	Unnatural choreography. Difficult to envision why the eyes would hold anger for so long.

the character. Seq.2 Tim.A and Seq.3 Tim.A also contained evidence of Automatic Appraisal but with a greater degree of subtlety, as the emotion starts off as a feeling of anxiety or horror respectively. The defining Universal Signals of both anger and fear were clear across all choreographies, making it difficult to suggest a candidate as an unclear animation.

Table 4.12 shows the subjective predictions for each EEC. Seq.1 and Seq.2 Tim.A were predicted to be the most authentic animations, with Seq.1 as the clearest animation of anger into fear. Seq.2 Tim.B and Seq.3 Tim.B were regarded as inauthentic choreographies, although no one EEC was identified as being particularly unclear.

4.5.3.5 Fear into disgust

For this transition, the most intuitive choreographies were those with overlapped timing. Of these, Seq.3 Tim.A proved to make more sense aesthetically, with the Overlapping Action from the mouth into the upper face clearly Staging the midpoint of the emotional shift. The alternative overlapped choreography – Seq.2 Tim.A – was almost as intuitive to produce, although implied a different (more complex) thought process. Increasingly throughout these animation studies it had been observed that simultaneous movement could hamper effective Staging, and this outcome was also observed for fear into disgust to an extent. Exaggeration was applied and the Timing manipulated to try to enhance the transition, making this chorography slightly less practical to work with. Nevertheless, the end animation clearly consisted of fear and disgust. The role of Secondary Action in the distinct timing choreographies was observed to be counterintuitive and problematic. This was particularly apparent in Seq.2 Tim.B, where the mixed expression of upper face disgust and lower face fear appeared unnatural.

From the psychological angle, simultaneous movement clearly demonstrated a Quick Onset of disgust. However, the Antecedent Event would have to be particularly potent to dispel a feeling of fear so quickly, and the transition ultimately appeared too smooth to be authentic. In this case, the fear expression could be regarded as a false display of anxiety. The simultaneous choreography may be suited to the context of watching a gruesome film without suppressing emotional displays. Seq.3 Tim.A, on the other hand, showed a greater degree of appraisal without weakening the effect of the Quick Onset, which in turn made the animation seem like a more genuine (and potentially context free) emotional shift. Seq.2 Tim.A also demonstrated thought process, but this version appeared extended with less of an Automatic Appraisal. As a result, this choreography would be better suited to a context where the Antecedent Event was observed and appraised cognitively. Distinct timing variations were less coherent. Although Seq.3 Tim.B was somewhat natural, the prolonged appraisal of the Antecedent Event appeared to create an inauthentic or staged expression of disgust. This choreography could potentially work in a context which allowed for a slower, more complex unfolding of disgust. Seq.2 Tim.B, on the other hand, appeared to be completely inauthentic as a straightforward shift in emotion. Other emotions or thought processes were apparent in the animation, with a look of anger or confusion in the transition. The subjective conclusions for each EEC are shown in Table 4.13. Seq.2 Tim.A and Seq.3 Tim.A were predicted to be the most clear and authentic expressions of fear into disgust, while Seq.1 was predicted to have the greatest degree of emotional clarity. Distinct timing choreographies were seen as less clear animations of fear and disgust, and thus the resulting animations could be confused with other emotions.

Table 4.13: An overview of the practitioner-researcher's observations for animations of fear into disgust.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Somewhat	Clear	Potentially Authentic	A quick shift from fear to disgust. The fear appears trivial, perhaps appropriate for viewing a film which has induced fear and disgust.
Seq.2 Tim.A	Yes	Clear	Authentic	Observation and cognitive appraisal of disgusting stimulus, thought process apparent.
Seq.2 Tim.B	No	Confusable	Inauthentic	Dazed or confused expression linking fear to disgust. Potentially contempt. Fairly unnatural, insincere.
Seq.3 Tim.A	Yes	Clear	Authentic / Sincere	Context independent. Clear and genuine shift in expression.
Seq.3 Tim.B	No	Clear / Potentially Confusable	Potentially Inauthentic	Context dependent, a slower development of fear to disgust, definite combination of these emotions at midpoint.

4.5.3.6 Disgust into surprise

The final transition to be animated was disgust into surprise. As with the animation of surprise in the previous study, simultaneous movement and upper face leading with overlapped timing emerged as the most intuitive choreographies in practice. Seq.1 was intuitive, although implied a strong surprise reaction to completely override the feeling of disgust, while Exaggeration was identified as the key to producing believable animation. Seq.2 Tim.A, on the other hand, was more flexible, and allowed for both Anticipation and the use of appropriate Overlapping Action. Seq.3 Tim.A was less intuitive, but still yielded a readable animation. Distinct timing choreographies were counterintuitive, as the use of Secondary Action in the jaw or eyes did not fit with a generic context. As a result, these choreographies proved more difficult and time consuming in practice.

Due to the nature of pure surprise, the expressions which transitioned to the expression most quickly were clearly more appropriate when framed by the emotional psychology literature. Seq.1, Seq.2 Tim.A and Seq.3 Tim.A could all be seen to result from the prototypical Antecedent Event of surprise, and the Quick Onset from disgust matched the kind of adaptive behaviour that would be expected. For Seq.1 and Seq.3 Tim.A, the appearance of disgust faded very quickly, indicating that the surprise reaction was particularly strong (at least relative to the intensity of the disgust emotion). Seq.2 Tim.A could be seen as being largely context free, as the eyes widened and brows rose just ahead of the jaw drop. This could represent Automatic Appraisal, starting with initial observation of the stimulus event followed by curiosity. The distinct timing choreographies by contrast contained elements of extended appraisal, suggesting that the experience of surprise was more complex (with Seq.2 Tim.B) or even unnatural (Seq.3 Tim.B). With the former, it could be proposed that there was evidence of a thought process, and as such the stimulus event was being cognitively appraised.

The subjective ratings assigned to each EEC are shown in Table 4.14. Seq.2 Tim.A and Seq.1 were predicted to be the most authentic and clear expressions of disgust into surprise, while the distinct timing choreographies were seen as being unclear (either due to the complexity of affective state or unnatural movement) and inauthentic.

Table 4.14: An overview of the practitioner-researcher's observations for animations of disgust into surprise.

Factors CEE	Intuitive	Clarity	Authenticity	Context
Seq.1	Yes	Clear	Authentic	Genuine response to an unbidden occurrence. A strong surprise to quickly override disgust.
Seq.2 Tim.A	Yes	Clear	Authentic / Sincere	Genuine surprise not controlled for. Automatic appraisal in response to an unexpected event.
Seq.2 Tim.B	No	Unclear	Inauthentic	Two stage surprise. Initial shock, followed by disbelief.
Seq.3 Tim.A	Somewhat	Clear	Potentially Authentic	Delayed surprise. Anticipated event, interest displayed initially, followed quickly by shock. Scope for extended appraisal.
Seq.3 Tim.B	No	Unclear	Inauthentic	No apparent context. Unnatural movement does not even convey a more complex thought process. A sarcastic display of faked emotions.

4.5.4 Discussion

As with the previous study, investigation into the role of emotional expression choreography in the animation of emotional transitions yielded detailed findings and predictions. Generally, it was found that distinct timing choreographies were least intuitive to work with, and that upper face leading with overlapped timing was typically the most artistically intuitive choreography. Once again, however, this conclusion could not be drawn for all of the transitions which were animated; for instance, it was found that it was more intuitive to animate surprise into happiness leading with the lower face, and that lower face leading with distinct timing worked particularly well when evaluated using the principles of animation. The application of Overlapping Action or Secondary Action was generally seen to enhance the Staging of animated transitions, while Anticipation and Exaggeration were vital when trying to make the most out of the simultaneous movement choreography. Structured reflection and evaluation of animation framed by Ekman's basic emotion characteristics provided an additional layer of analysis, demonstrating how the psychological understanding of the nature of emotion could inform animation production and observation. In most instances, consideration of the Antecedent Event was the key to proposing potential contexts for each EEC, while the level of Automatic Appraisal apparent in each animation underpinned predictions of emotional purity and authenticity. Variation in expression sequence and timing altered the appearance of the Universal Signals of each emotion, which were evaluated by the practitioner-researcher to determine the potential clarity of the

Table 4.15: Final subjective predictions for expression transition animation authenticity and clarity.

Animation	Authentic	Inauthentic	Clear intended emotions	Unclear intended emotion
Surprise into Happiness	Seq.3 Tim.A or Seq.3 Tim.B	Seq.1 or Seq.2 Tim.B	Seq.3 Tim.A or Seq.3 Tim.B	Seq.2 Tim.A or Seq.2 Tim.B
Happiness into Sadness	Seq.2 Tim.A	Seq.3 Tim.B	Seq.1 or Seq.2 Tim.A	No prediction
Sadness into Anger	Seq.2 Tim.A	Seq.3 Tim.A or Seq.3 Tim.B	Seq.2 Tim.A	Seq.3 Tim.A or Seq.3 Tim.B
Anger into Fear	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B	Seq.1	No prediction
Fear into Disgust	Seq.2 Tim.A or Seq.3 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B	Seq.1	Seq.2 Tim.B or Seq.3 Tim.B
Disgust into Surprise	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B

animations. As before, then, this study led to a range of substantiated predictions (Table 4.15) to carry forward to a study of observer perception (Chapter 5). Potential contexts were also identified, and these would later be compared with the findings of qualitative research (Chapter 6).

4.6 Exposition of animation and process

Throughout the animation production and evaluation process, exposition of the work in progress played a crucial role. Exhibition and discussion of the animation and methodology to small, critical audiences took place regularly, primarily to parties of academics, politicians, and games industry professionals visiting the institution (see Figure 4.13). These short exhibitions were useful in gathering immediate feedback on the research, its application, rationale, and the validity of the artistic methods. For example, in

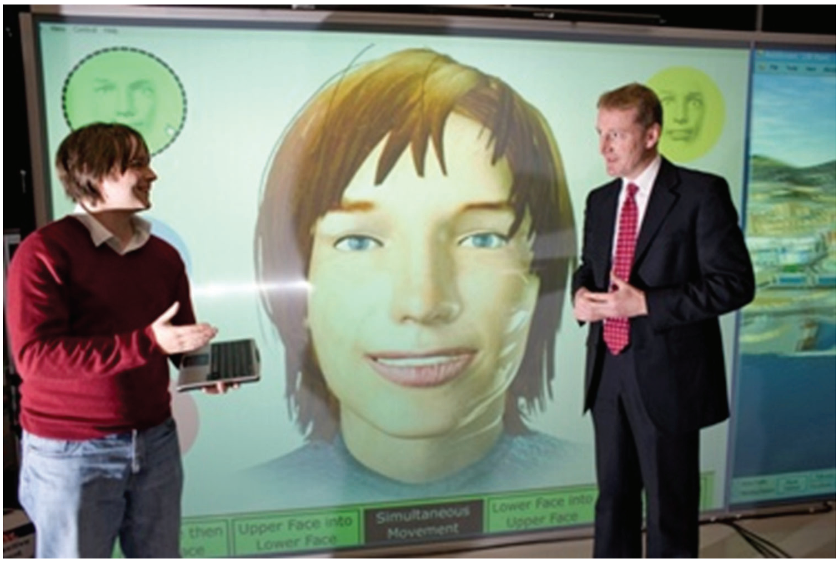


Figure 4.13: Discussion of Emotional Avatars performative methods and results with Tavish Scott MSP, 13th January 2010.

2009, the practitioner-researcher was given the opportunity to exhibit animation and discuss the performative methodology with Carole Gray (informal meeting on 1st of October 2009). As the methodology was developed based largely on the work of Gray and Malins (2004), this meeting was greatly informative and led to refinement of analytical methods.

In addition to these short expositions of Emotional Avatars research, larger planned exhibitions were conducted at various stages of the project. The first exposition of emotional expression animation took place in White Space at the University of Abertay Dundee in 2008. The event lasted for approximately 6 weeks, starting on the 14th of November. Most of the visitors were staff and students of the university, who were invited to the opening evening through a news story on the Abertay web portal. The purpose of the first exhibition was to present the output of preliminary animation studies and to gather visitor feedback on the appearance of various animations when compared with each other. The primary means of collecting feedback was

Figure 4.14: Visitor participation in animation evaluation at the 2008 Emotional Avatars exposition. Various research questions were posed, with the video content changing daily.

through voting (see Figure 4.14). Visitors were asked to watch three animations that were presented side by side, and then rank the animations according to perceived intensity or perceived authenticity. The animations and ranking factor changed daily. Posters and further imagery from the first exposition are detailed in Appendix XVI. The second exposition of emotional expression animation concerned the animation output from Animation Studies 1 and 2, but this time the focus was on the artistic process and subjective interpretations of the practitioner-researcher. The exposition took place in White Space at the University of Abertay Dundee from October to December 2009, and primarily consisted of poster displays and visitor books. An interactive demonstration of animation was also placed in the exposition (see Appendix XII). Posters and further imagery from the second exposition are detailed in Appendix XVI.

In order to present the process and findings to a non-academic audience, elements of the second White Space exposition were exhibited at the Science in the City event at the Sensation Science Centre in Dundee[1]. This event took place over the 31st of January and 1st of February 2010. The 31st of January was mainly attended by families, while the 1st of February was focussed on school visits. As such, most of the visitors were younger children, teenagers, parents, or teachers. The purpose of this exposition was to present a simplified demonstration of the planning phase of the animation inquiry cycle (using coloured pencils and a mirror to draw faces), engage the visitors with interactive animation (see Appendix XII), and get people to think about choreography by acting out and talking about expressions (see Figure 4.15). Over the course of the two days, teenage and adult visitors were asked for their thoughts on the concept of choreographing expressions, and also on the use of artistic processes to learn more about facial expressions. Visitors who agreed to contribute their thoughts were informally interviewed, with their feedback recorded in a comments book maintained by the researcher. Due to the diversity of the audience, in terms of both age and research experience, questions were kept as simple as possible, and most questions prompted some form of activity (e.g. asking the visitor to interact with the animation, act out an expression using the mirror, or draw what they thought an expression should look like). Details of this exposition and visitor feedback are provided in Appendix XVI.

[1] Information on the centre and the event can be accessed online at http://www.sensation.org.uk/

Figure 4.15: Public exposition at Science in the City event, January-February 2010. This event was primarily aimed at children and families. Visitors were invited to; (a) interact with choreographed emotional expression animation, (b) learn about the Emotional Avatars animation inquiry cycle through activity and (c) create drawings of facial expressions.

4.7 Chapter summary

Through the execution of performative studies of emotional expression choreography it was demonstrated that, not only could arts practice be used to investigate the animation of facial expressions, but also that viable and informative findings could be derived through analysis of arts-based materials. The research discussed in this chapter was conducted entirely within the confines of the studio, where the practitioner-researcher generated animation based on subjective interpretations of movement and formed conclusions founded on personal reflection and evaluation. The subjectivity of this approach was clearly declared and the validity of the arts-led methodology was supported by the growing visual research literature (e.g. Gray and Mailns, 2004; Sullivan, 2009). Due to the subjective nature of the research presented in this chapter, the performative methodology discussed in Chapter 3 underlined the importance of framing the research. As such, the principles of animation (Thomas and Johnston, 1981) and Ekman's basic emotion characteristics (Ekman, 1992) were used to inform animation produced and to analyse final animated expressions. A wealth of research materials were generated through this period of research, including expression videos, sketches, posed expressions, animations, journals, and structured reflection. These materials were included as figures and appendices, allowing for a closer examination of how the practitioner-researcher created animation and derived conclusions from the results. Additionally, exposition of the research and animation throughout the project was essential for maintaining ongoing peer review and public critique. Details of major exhibitions and presentations were provided in this chapter.

To return to the project aims initially laid out in section 3.1, the goal of the performative phase of research was to determine whether creative animation practice could reveal a means of choreographing emotional facial expressions. This goal was thoroughly addressed by the practice-based research presented in this chapter. Firstly, artistic studies of naturalistic and acted expression videos helped the practitioner-researcher to ascertain how expressions moved in nature and in performance. By picking apart naturalistic expressions to draw out the details that were most important to animation, the practitioner-researcher observed spatial and temporal attributes of genuine expressions of emotion. Similarly, artistic observation of acted expressions revealed potential sequences and timings within the face for dramatically posed emotions. These studies led to the initial proposal of emotional expression choreography as being the sequence, timing, duration, and severity of regional facial movement. Subsequent experimentation in the studio revealed the potential for choreographing animated expressions using these categories. This period of research involved a great deal of trial and error, iterative animation production, and reflection before the decision to settle on the sequence and timing of two facial regions (the upper and lower face) was made. The simplicity of the final proposal of emotional expression choreography – which consisted of just five configurations of movement – set up two successful animation studies. The first of these sought to examine the choreographed animation of the six universal expressions. Cyclic studio practice generated a range of results in the form of refined animated expressions. Evaluation of the results (framed by the principles of animation and emotional psychology literature) in turn led to a series of subjective (but informed) conclusions regarding the potential impact of choreographed expressions. This included a reflection on how intuitive various choreographies were in practice, a prediction of the clarity and authenticity of final animation videos, and proposed contexts for animations. The findings of the second study – which examined the role of choreography as applied to emotion transitions – added to these findings, offering insights and predictions which would broadly be of use to both animation practitioners and computer animation researchers.

By forming detailed conclusions and predictions regarding the role of EEC, the performative methodology and practice-based findings demonstrated conclusively that animation practice could reveal a means of choreographing believable emotional facial expressions. This, however, addressed only the first of three primary research questions posed in Chapter 3. After artistic predictions were made, the next goal was to determine whether the practitioner-researcher's subjective conclusions (in particular the predicted clarity and authenticity of choreographed animations) could anticipate how observing audiences would perceive the final animations. The subsequent quantitative phase of research was established in order to address this research question.

Chapter 5
Measuring observer perception:
audience interpretation of choreographed animations

In terms of understanding how emotional expression choreography could be applied to facial animation creatively, the performative research discussed in the previous chapter proved to be a practical and sensible approach. Through iterative animation development and reflection, a range of in-depth artistic observations were made regarding the role of EEC in practice. However, this research ultimately revealed a highly subjective interpretation of emotional expression performance. As regards perception of temporally configured expressions, the artistic observations served only to predict how audiences might react to the animations. In order to demonstrate that EEC could manipulate observer perception, a more scientific approach was required. In this chapter, the development and execution of experimental methods for measuring and assessing observer perception of animated expressions will be discussed. Firstly, the early phases of experiment design and pilot testing will be covered in 5.1. Section 5.2 will deal with the first main experiment designed to assess the effect of EEC on observer perception. This experiment sought to determine whether the final framework of EEC (4.3.1) had a measurable impact on observer interpretation of emotional expression animations (see 4.4). The final experiment – which was a repeat of the first experiment, but using choreographed emotional expression transitions as stimuli (see 4.5) – will be covered in section 5.3. A summary of the findings and overall conclusions will then be discussed in 5.4.

As covered in Chapter 3, the methodological design for the Emotional Avatars project is based on the convergence and taxonomy development models of mixed methods research (3.5). Performative research was initially conducted in order to iteratively develop creative animation to be used as stimuli, but also to generate artistic predictions informed by cyclic practice. In essence, the performative phase of research was the exploratory stage – the development of EEC taxonomy – while the second, quantitative phase of research into audience perception of animation was designed to be the scientific testing stage of the project. Therefore, the purpose of the following experiments was not only to establish whether EEC could significantly affect observer perception of animated expressions, but also to determine whether cyclic performative research could be embraced as a means of generating accurate predictions for scientific study.

5.1 Development of the experimental method

Experimental methods for assessing observer perception of expressions commonly revolve around measurement of participant judgement, typically using ratings scales (see 3.3). This approach was deemed the most appropriate for assessing animated facial expressions produced as part of the Emotional Avatars research. In order to develop and test the effectiveness of this method and the suitability of various measures, a series of pilot experiments were conducted. These experiments made use of facial expression stimuli generated through the initial studies discussed in Chapter 4. Firstly, the naturalistic expressions (recorded as part of the study to create new reference material – 4.1.1) were incorporated into a perception study designed to record participant interpretation using a range of measures. Two batches of animation were then tested on observers; animation that explored the role of expressional severity and sequence (see 4.3). Finally, to address an issue identified in the performative research, images of disgust expressions were manipulated and tested to determine what factors may cause confusion between disgust and anger. The main outcomes of these experiments shall be covered in this chapter. Detailed accounts of the experiments are contained within the associated appendices.

5.1.1 Observer perception of naturalistic expressions

The first pilot experiment was conceived to assess the effectiveness of a range of measures appropriate for testing observer perception. Stimuli were drawn from the study discussed in 4.1.1, which generated a series of naturalistic expression videos. The design and results of this study was initially presented in Sloan et al. (2008), which is included as Appendix XVII. Observers were requested to view naturalistic expression videos in a randomised order and to complete the following tasks; rate their identification of 'happiness', 'sadness', 'anger', 'fear'. 'disgust', 'surprise', and 'other' on a 5-point scale from 'strongly disagree' to 'strongly agree', rate the perceived strength of emotion on a 5-point scale from 'not present' to 'very strong', and rate the authenticity of emotion on a 5-point scale from 'fake' to 'genuine'. While some indication of observer perception was recorded using these measures, the selection of measures caused issues for both the participants (who were burdened with ticking many boxes after each trial) and analysis. Expressions of happiness and sadness were clearly and accurately identified, although participants had difficulty in recognizing the remaining expressions (particularly fear). While the naturalistic (non-posed) expressions were perhaps difficult to decipher, and lack of familiarity with the subjects in the videos could have caused in issue with expression discrimination, the use of a rating scale for emotion identification was deemed problematic. Ratings for emotional intensity appeared to correlate with ratings for identification, a finding which was replicated in the subsequent experiment. No differences were found between expressions for ratings of authenticity. As a consequence of this experiment, steps were taken to refine and improve the experimental design and measures.

5.1.2 Observer perception of animated expressions at varying levels of severity

The next experiment contained a refinement in the measures taken, and made use of animated stimuli produced as part of an early study into emotional expression severity (see 4.3.1). The results of this study were reported in Sloan, Cook, and Robinson (2009), which is included as Appendix XVIII. For this experiment, the following questions were posed after each viewing of the eighteen animated emotional expressions; which of the following emotions were expressed (choosing one or more from 'happiness', ‘sadness’, ‘anger’, ‘fear’. ‘disgust’, ‘surprise’, and ‘other’), how confident are you that this emotion was expressed (using a 5-point Likert scale from ‘not confident’ to ‘very confident’), how intense was this emotion? (using a 5-point Likert scale from ‘low intensity’ to ‘high intensity’), and how authentic was this emotional expression? (using a 5-point Likert scale from ‘fake’ to ‘genuine’). The results indicated an improvement in the use of these measures from the previous experiment, with correlations identified between confidence of identification and perceived intensity, and confidence of identification and perceived authenticity. For all animations except fear, ratings for emotional intensity were seen to match the severity of emotional expression from the study described in 4.3.1. As such, these measures were carried forward into the next experiment, which was designed to assess whether observer perception of emotion was affected by manipulation of facial region sequence.

5.1.3 Observer perception of regionally sequenced animated expressions

This experiment built upon the approach previously developed for assessing perception of animated expressions at varying degrees of expressional severity. In this case, the purpose of the experiment was to assess observer perception of the onsets and offsets of three emotions (sadness, fear, and disgust) which were animated by the practitioner-researcher using a range of thirteen sequence combinations (discussed in Appendix X and exhibited in Appendix XI). The thirteen sequences were based on manipulation of the sequential movement of the brows, eyes, and mouth regions. The design and measures of the previous experiment were carried over into this experiment. The design, analysis, and results of this experiment were reported in Sloan, Cook, and Robinson (2009), which is included as Appendix XVIII. Ultimately, this experiment produced inconclusive results. It was not possible to discern whether there were significant differences in observer perception when regional sequence was manipulated, including identification of emotion and perceived authenticity. This was attributed to three factors; the high number of levels for the sequence condition (thirteen), the number of rating scales participants had to address after each viewing, and the small size of the scales (5-points). The first of these problems was addressed by reducing the number of levels from thirteen to five when the final framework of EEC was proposed (see 4.3.1). To address the problems with rating scales, the experimental design was subsequently updated to make use of 7-point scales, while the rating scales for observer confidence and intensity of emotion were removed. The streamlined design catered for an explicit focus on expression identification and perceived authenticity, and was introduced for the first major assessment of the final framework of EEC (discussed in 5.2).

5.1.4 Observer confusion between anger and disgust expressions

A final study was conceived to tackle an issue first identified in the performative phase of the research; the potential for confusion between expressions of disgust and anger. This issue was identified when sequential movement of facial regions was considered. Specifically, it was found that disgusted expressions could more closely resemble angry expressions when precedence was given to the upper face (see 4.4.3.5). This experiment was designed to determine whether manipulation of the three facial regions (brows, eyes, and mouth) using the facial rig would affect observer identification of disgust expressions. A full account of the experiment, including design, analysis, and results, is included as Appendix XIX. The findings of this experiment clearly showed that facial region plays an important role in the interpretation of prototypical disgust expressions. Even though the specific regional appearances of the universal expression of disgust (Ekman and Friesen, 1975) were used in the posed expressions, observers opted to rate the expressions as being more representative of anger when they were presented with just the eyebrows, or with the combination of eyebrows and eyes. Conversely, when presented with just the mouth region, or with the combination of mouth and eyes, observers were more prepared to rate the expressions as being representative of disgust. Observation of the eyes alone (without the eyebrows) resulted in participants being unwilling to declare the expressions as either anger or disgust. Observation of the combination of eyebrows and mouth appeared to create confusion (likely caused by the conflict between the angry-looking brows and disgusted-looking mouth), as participants were also unable to identify these expressions as either emotion. Broadly, it could therefore be concluded that the lower face is crucial to identification of disgust, while presentation of the upper face may result in confusion with anger.

5.2 Experiment 1: observer perception of choreographed emotional expressions

In the performative phase (discussed in Chapter 4) and in the evaluation of the previous pilot experiments, the initial concept of emotional expression choreography was found to be complex to the point that it was unwieldy in both practice and experimentation. Originally, EEC was proposed as being the sequence, timing, severity, and duration of regional facial movements during dynamic expressions, with three facial regions (brows, eyes, and lower face) manipulated by the animator. These three regions were derived from the work of Ekman and Friesen (1975). This approach proved difficult to implement in animation practice (see 4.3) and in experimentation (5.1). In a previous experiment, the manipulation of three facial regions led to the application of thirteen levels of choreography based on sequence manipulation alone. This in turn resulted in an experiment design that was too complex to yield meaningful results. To cover all six emotional expressions (plus the other elements of EEC, such as timing) proved problematic and unworkable under such circumstances. Furthermore, the use of three regions was seen as an unnecessary complication in the artistic study of choreographed facial animation (see 4.3.1).

As such, the concept of EEC was simplified so that it fundamentally concerned the sequence and timing of just two facial regions; the upper and lower face. This allowed for a more in-depth artistic study of facial animation using EEC as a framework (see 4.4), a consequence of which was a series of facial animations based on the creative application of two-region emotional expression choreography. Accompanying these new facial animations were detailed artistic observations that resulted from iterative creative practice (see 4.4.3). The current experiment was therefore designed as a means to assess audience perception of these choreographed facial animations, in order to determine whether the revised EEC framework affected how observers interpreted facial animation, and to ascertain whether artistic observations could act as informed and accurate predictions for empirical research. The results of this experiment were initially reported in Sloan et al. (2010a; 2010b).

5.2.1 Research questions

The fundamental research question for the current experiment was whether EEC could affect observer perception of animated expressions. The choreographies adopted for study in this experiment consisted of two facial regions (upper and lower face) and five levels (see 4.3.1). With this in mind, the research questions for this experiment were as follows:

I. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect observer identification of emotion when viewing emotional expression animation?
II. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect the perceived authenticity of emotional expression animations?

III. Do the results for observer identification and perceived authenticity of creative emotional expression animations align with the artistic observations and predictions of the practitioner-researcher?

Therefore, it was predicted that creatively applied emotional expression choreographies would affect identification of emotion, perceived authenticity of expressions, and that the findings would align with the observations of the practitioner-researcher.

5.2.2 Experiment design

The purpose of the current experiment was to assess observer perception of the thirty videos produced as a result of animation study 1 (discussed in 4.4 and exhibited in Appendix XII). These videos depicted the onsets of the six universal emotional expressions (happiness, sadness, anger, fear, disgust, and surprise), which were produced artistically using the five pre-determined EECs. The five choreographies were as follows; upper and lower face regions move together (Seq.1), upper face region leads lower face region with overlapped timing (Seq.2 Tim.A), upper face region leads lower face region with distinct timing (Seq.2 Tim.B), lower face region leads upper face region with overlapped timing (Seq.3 Tim.A), and lower face region leads upper face region with distinct timing (Seq.3 Tim.B). As such, each of the six emotional expressions were animated using five levels, with each level based on the artistic manipulation of upper and lower face sequence and timing.

5.2.2.1 Participants

Participants were a mixture of students, academic staff, and support staff of the University of Abertay, as well as members of the public not affiliated with the university. The aim was to recruit as balanced a group of participants as possible so as to enable a study on the effects of EEC on a general audience. Participants were recruited through internal and external advertising using both printed and online digital advertisement methods, and were not paid for their time. Thirty-two people (18 female, 14 male) participated in the experiment. Participants were split two groups; group 1 (16 participants, 9 female, 7 male) and group 2 (16 participants, 9 female, 7 male).

5.2.2.2 Materials

Observer perception was assessed using two measurements; observer identification of emotion, and perceived authenticity of the animated expressions. Measurements taken in the previous experiment (i.e. observer confidence and perceived emotional intensity) were disregarded in order to simplify the experiment. To take these measurements, participants watched all thirty videos twice over two blocks (A and B) and answered a single question after each viewing. In block A, participants were asked to identify the emotion(s) present in the video which they had just observed. Participants were able to select one or multiple from the following options; 'happiness', 'sadness', 'anger', 'fear', 'disgust', 'surprise', 'other emotion', 'no emotion', and 'don't know'. In block B, participants were asked to rate how authentic they thought the emotional expression animation was, using a 7-point Likert scale from 'not authentic' to 'authentic'. Participants were told to consider an animation that looked unbelievable, unnatural, or unrealistic as being 'not authentic', whereas an animation that looked believable, natural, or realistic should be considered 'authentic'. The researcher encouraged all participants to use the full scale if they were confident that an animation was authentic or not authentic. Participants were also given the option of clicking a button labelled 'I missed the clip' after a video finished playing, which they were instructed to use if they were distracted while viewing the video. This option skipped the current video all together, meaning that the participant did not submit any data for the video.

The experiment took place in a private room in the Epicentre building at the University of Abertay. The participants – who sat in isolation for the duration of the experiment – watched all thirty videos twice, displayed at a resolution of 720x576 on a 1680x1050 screen. The experiment lasted approximately 45 minutes.

5.2.2.3 Procedure

The decision to show all thirty videos to participants twice over two blocks was made in order to avoid participant fatigue, and to ensure that participants answered all questions promptly while the current video was still fresh in their minds. The issue of asking participants to answer multiple questions after a single viewing was identified as a potential flaw in the previous experiment design, as discussed in 5.1. However, the redesign for this experiment introduced the risk of there being an order effect on how participants answered questions, depending on which question they were asked first, and whether a second viewing would significantly manipulate their interpretation of the animation. As such, participants were split into two groups (1 and 2). Group 1 participants completed block A followed by block B, while group 2 participants completed block B followed by block A.

Data were examined using a number of statistical analyses. Firstly, the Mann-Whitney test was used to determine whether there were any other factors (participant sex or participant group) that influenced participant perception (section 5.3.3.1). To assess observer identification of the intended emotion (5.3.3.2) and other emotions (5.3.3.3), the total numbers of emotion identifications were assessed using the chi-square test and Wilcoxon signed ranks test. Finally, to ascertain whether EEC affected the perceived authenticity of animation, Friedman tests and Wilcoxon signed ranks tests were used (5.3.3.4). SPSS was used to conduct all statistical analyses.

5.2.3 Results

It is recommended that the reader open the multimedia matrix (Appendix V) and browse to the relevant expressions, in order to view final animations for each EEC while reading this results section.

5.2.3.1 Testing for effects of confounding variables

The Mann-Whitney statistical test was selected to determine whether participant sex or block order (participant group) had an effect on participant identification or rating of animations. Participant identification data for all thirty videos was compiled into a single data set. The critical *p* value was corrected for the number of tests[1] (n = 30) resulting in a *p* value of .0017. Mann-Whitney tests revealed no significant effects of participant sex ($p > .369$) or participant group ($p > .094$) on identification of emotion. To assess whether participant sex or question order affected the perceived authenticity of expression animations, participant ratings for all thirty videos were compiled into a single data set and the critical *p* value was again corrected to .0017 to account for the number of tests. The Mann-Whitney test results showed that neither participant sex ($p > .293$) nor participant group ($p > .011$) had a significant effect on observer rating of authenticity. As neither participant sex nor question order had a significant effect on either identification of emotion or rating of authenticity, further statistical tests were selected to determine whether the use of EEC affected how observers interpreted the animation.

5.2.3.2 Identification of intended emotion

The primary concern when assessing observer identification of emotion was to determine whether participants correctly identified the intended emotion in all expression animations, and to establish whether EEC affected observer identification. To test this, chance identification rates

[1] Bonferroni correction described by Howell (1997) pp.362-369

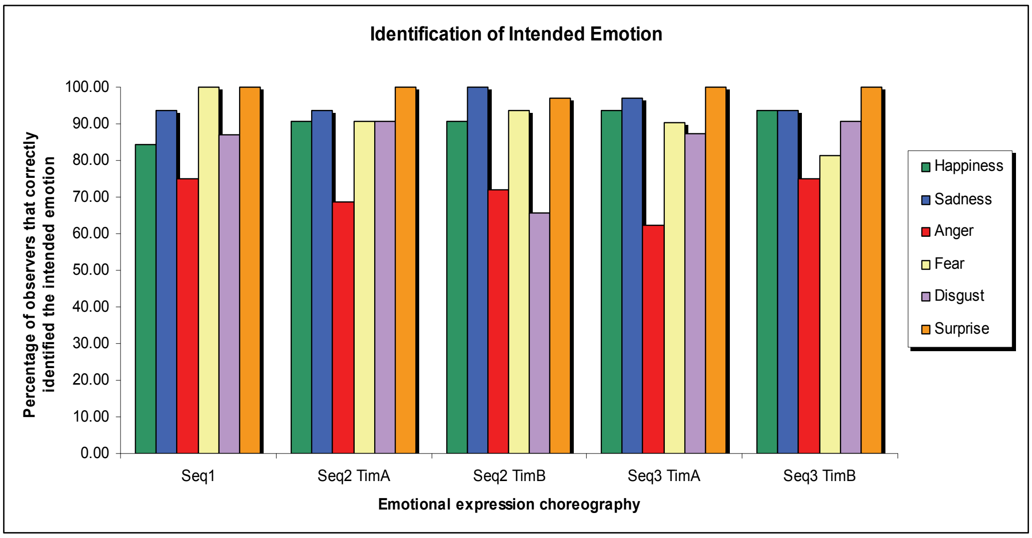


Figure 5.1: Identification rates (%) for the intended emotion in all thirty emotional expression animations.

suggested by Ekman (1994) were adopted as a baseline. These were; 50% for happiness, 33% for surprise, and 25% for sadness, anger, fear and disgust.

As shown in Figure 5.1, all animations were identified as the intended emotion above the respective chance rates, irrespective of EEC. To test whether the identification rates were significantly above Ekman's (1994) suggested chance rates, the chi-square test was used to compare the observed number of correct identifications to the expected number of identifications according to the chance rates. For all emotions and all EECs, the intended emotion was identified significantly above chance[1], as summarised in Table 5.1. It could therefore be proposed that any of the five EECs could be used to successfully animate any of the six expressions, since observers should be able to identify the intended emotion well above chance. This evidence addressed the first research question for the experiment, demonstrating that choreography choice did not negate identification of the

[1] Where the critical p value was corrected for the number of tests, resulting in a p value of .0017.

Table 5.1: Results of chi-square tests comparing identification of intended emotion (Observed n) to Ekman's chance rates (Expected n) for each emotional expression animation.

Emotion	EEC	Chi-Square result	Expected *n*	Observed *n*
Happiness	Seq1	$\chi^2(1) = 15.125$, $p < .001$, $n = 32$	16	27
	Seq2 TimA	$\chi^2(1) = 21.125$, $p < .001$, $n = 32$	16	29
	Seq2 TimB	$\chi^2(1) = 21.125$, $p < .001$, $n = 32$	16	29
	Seq3 TimA	$\chi^2(1) = 24.5$, $p < .001$, $n = 32$	16	30
	Seq3 TimB	$\chi^2(1) = 24.5$, $p < .001$, $n = 32$	16	30
Sadness	Seq1	$\chi^2(1) = 80.667$, $p < .001$, $n = 32$	8	30
	Seq2 TimA	$\chi^2(1) = 80.667$, $p < .001$, $n = 32$	8	30
	Seq2 TimB	$\chi^2(1) = 92.205$, $p < .001$, $n = 31$	7.8	31
	Seq3 TimA	$\chi^2(1) = 88.167$, $p < .001$, $n = 32$	8	31
	Seq3 TimB	$\chi^2(1) = 77.688$, $p < .001$, $n = 31$	7.8	29
Anger	Seq1	$\chi^2(1) = 42.667$, $p < .001$, $n = 32$	8	24
	Seq2 TimA	$\chi^2(1) = 32.667$, $p < .001$, $n = 32$	8	22
	Seq2 TimB	$\chi^2(1) = 37.5$, $p < .001$, $n = 32$	8	23
	Seq3 TimA	$\chi^2(1) = 24$, $p < .001$, $n =32$	8	20
	Seq3 TimB	$\chi^2(1) = 42.667$, $p < .001$, $n = 32$	8	24
Fear	Seq1	$\chi^2(1) = 88.167$, $p < 001$, $n = 32$	8	31
	Seq2 TimA	$\chi^2(1) = 73.5$, $p < 001$, $n = 32$	8	29
	Seq2 TimB	$\chi^2(1) = 80.667$, $p < 001$, $n = 32$	8	30
	Seq3 TimA	$\chi^2(1) = 70.548$, $p < 001$, $n = 31$	7.8	28
	Seq3 TimB	$\chi^2(1) = 54$, $p < 001$, $n = 32$	8	26
Disgust	Seq1	$\chi^2(1) = 63.753$, $p < .001$, $n = 31$	7.8	27
	Seq2 TimA	$\chi^2(1) = 73.5$, $p < .001$, $n = 32$	8	29
	Seq2 TimB	$\chi^2(1) = 28.167$, $p < .001$, $n = 32$	8	21
	Seq3 TimA	$\chi^2(1) = 66.667$, $p < .001$, $n = 32$	8	28
	Seq3 TimB	$\chi^2(1) = 73.5$, $p < .001$, $n = 32$	8	29
Surprise	Seq1	$\chi^2(1) = 63.701$, $p < .001$, $n = 32$	10.7	32
	Seq2 TimA	$\chi^2(1) = 63.701$, $p < .001$, $n = 32$	10.7	32
	Seq2 TimB	$\chi^2(1) = 58.142$, $p < .001$, $n = 32$	10.7	31
	Seq3 TimA	$\chi^2(1) = 63.701$, $p < .001$, $n = 32$	10.7	32
	Seq3 TimB	$\chi^2(1) = 63.701$, $p < .001$, $n = 32$	10.7	32

intended emotion. However, Figure 5.1 indicates that there was variation in how well particular emotional expressions were identified when different choreographies were applied. While identification rates for happiness, sadness, and surprise were broadly the same regardless of EEC (the greatest difference between a pair of choreographies was < 10%) there were larger differences between pairs of choreographies for fear, anger, and disgust. These differences can be seen in Figures 5.2, 5.3 and 5.4. For fear, the largest difference in intended emotion identification rates was between Seq.1

(96.88%) and Seq.3 Tim.B (81.25%), a difference of 18.75%. For Anger, the largest difference was between Seq.1 / Seq.3 Tim.B (both 75%) and Seq.3 Tim.A (62.5%), a difference of 12.5%. Finally, disgust was poorly identified as the intended emotion in Seq.2 Tim.B (65.63%) compared to all other EECs; Seq.1 (87.1%, a difference of 21.47%), Seq.2 Tim.A (90.63%, a difference of 25%), Seq.3 Tim.A (87.5%, a difference of 21.87%) and Seq.3 Tim.B (90.63%, a difference of 25%). To assess whether these differences were statistically significant, the chi-square test was used to compare identification rates for the intended emotion, where the expected *n* of positive identifications was equal to the identification rate of the least well identified choreography (see Table 5.2). A Bonferroni correction was applied to account for the number of tests (5 choreographies for each emotion) giving a critical *p* value of .01.

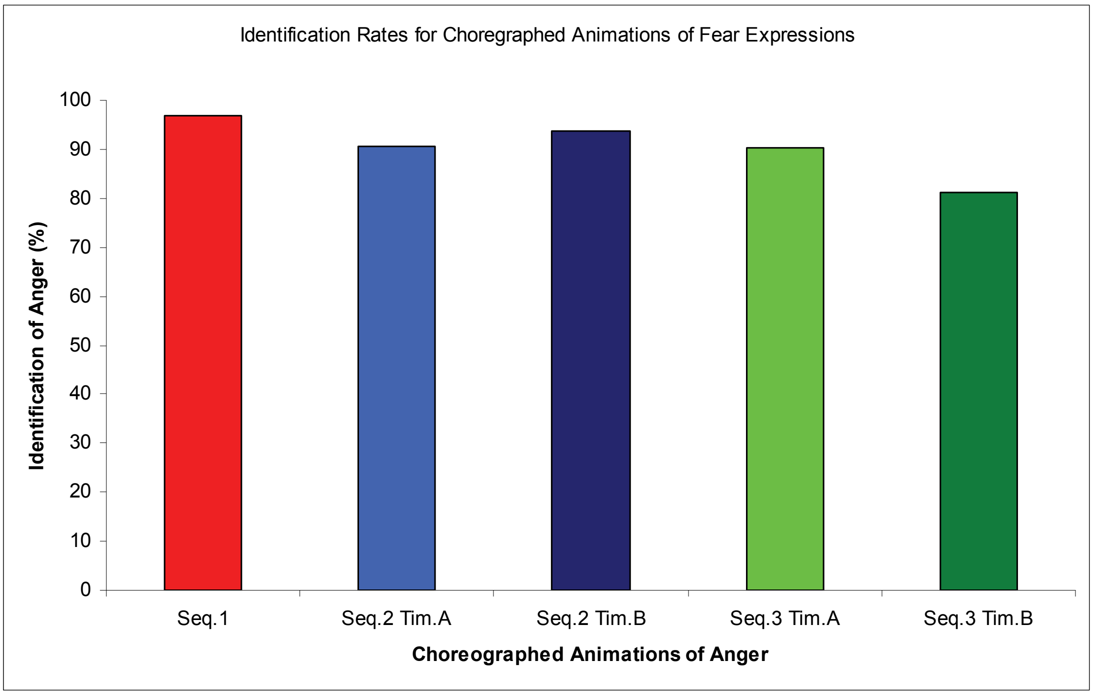


Figure 5.2: Identification rates for fear animations.

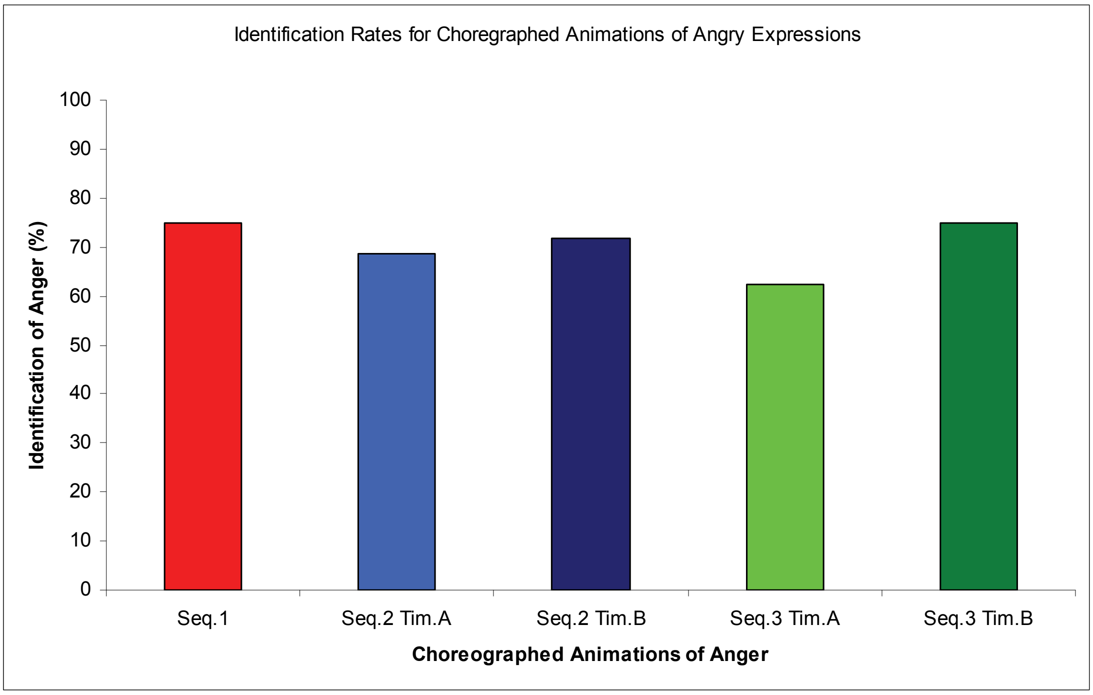


Figure 5.3: Identification rates for anger animations.

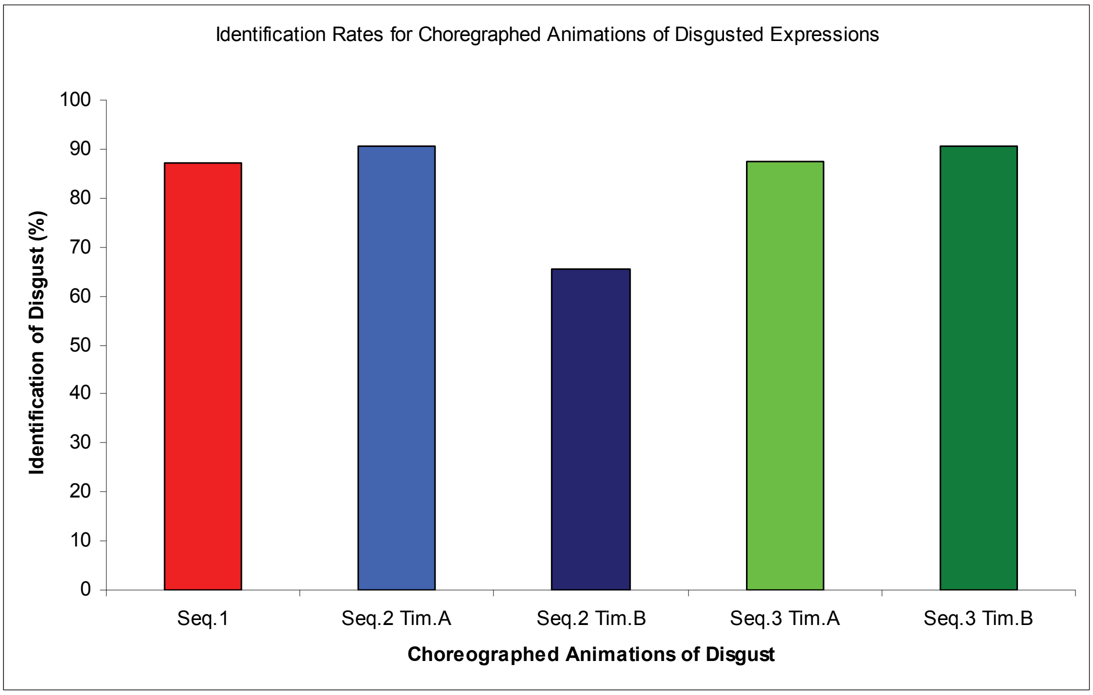


Figure 5.4: Identification rates for disgust animations.

Table 5.2: Chi-square results for comparisons between intended emotion identification rates for emotional expressions. EEC 1 was the least well identified in each comparison, while EEC 2 was correctly identified by at least 10% more participants. Expected *n* is derived from the identification rate of EEC 1, while Observed *n* is the number of correct identifications for EEC 2. Critical *p* value = .01.

Animation	Choreographies Compared		Chi-Square result	Expected *n*	Observed *n*
	EEC 1	EEC 2			
Fear	Seq.3 Tim.B	Seq.1	$\chi^2(1) = 5.128$, $p < .025$, $n = 32$	26	31
Anger	Seq.3 Tim.A	Seq.1	$\chi^2(1) = 2.133$, $p < .145$, $n = 32$	20	24
Anger	Seq.3 Tim.A	Seq.3 Tim.B	$\chi^2(1) = 2.133$, $p < .145$, $n = 32$	20	24
Disgust	Seq.2 Tim.B	Seq.2 Tim.A	$\chi^2(1) = 4.985$, $p < .004$, $n = 32$	21	29
Disgust	Seq.2 Tim.B	Seq.3 Tim.A	$\chi^2(1) = 6.785$, $p < .01$, $n = 32$	21	28
Disgust	Seq.2 Tim.B	Seq.3 Tim.B	$\chi^2(1) = 4.985$, $p < .004$, $n = 32$	21	29

As shown in Table 5.2, the difference between identification rates for fear (Seq.3 Tim.B and Seq.1) was non-significant. Similarly, for anger, the differences between identification rates for Seq.3 Tim.A compared to both Seq.1 and Seq.3 Tim.B were non-significant. However, for disgust, the difference between identification rates was significant in all three tested cases: the Seq.2 Tim.B animation was less well identified as disgust than Seq.2 Tim.A, Seq.3 Tim.A and Seq.3 Tim.B. These observed differences roughly aligned with some of the predictions that resulted from iterative artistic practice and reflection (see 4.4.3). It was predicted that fear would become less effective as an animation if the mouth led with distinct timing, that anger leading with the mouth may be confusable with other emotions, and that disgust would be less clear if the appearance of the lower face sneer was delayed. In addition, the findings of the previous study of observer confusion between disgust and anger expressions (5.1.4) predicted that leading with the upper face in expressions of disgust would negatively affect identification. The knowledge that choosing a particular choreography over another could result in more than 10% of the audience being unable to identify an intended emotion is certainly useful to a practicing animator. However, this may well be a fact that is difficult to prove statistically. While it would appear that choreographies Seq.3 Tim.B and Seq.3 Tim.A result in expression animation which is more difficult to identify as fear or anger respectively, only with disgust could it be said that choreography selection can significantly degrade observer identification of the intended emotion. In this case, it could be proposed that Seq.2 Tim.B (upper face leading with distinct timing) is the least effective EEC when trying to create a clear animation of disgust, and that Seq.2 Tim.A, Seq.3 Tim.A and Seq.3 Tim.B prove to be more effective alternatives.

5.2.3.3 Identification of other emotions

As participants had the ability to select multiple options when they were asked to identify the emotion in each animation, it was possible to highlight where observers picked up on other (non-intended) emotions within the animations. Table 5.3 shows the identification rates (%) for each emotion identification option, and for each animation. For most animations, the intended emotion was the only emotion to be identified above Ekman's (1994) chance rates. All animations of fear were identified as fear primarily, but also as surprise just below the chance rate of 33%. For animations of anger and disgust, however, other emotions were identified above chance. For all five

Table 5.3: Emotion identification rates (%) for each emotional expression animation. Identification of; happiness, sadness, anger, fear, disgust, surprise, other emotion, and no emotion. Intended emotion identification rates are highlighted in green. Other (non-intended) emotions that were identified above chance rates are highlighted in yellow.

Intended Emotion	EEC	Hap	Sad	Ang	Fea	Dis	Sur	Oth	No
Happiness	Seq1	84.4	0	0	0	0	0	9.4	3.1
	Seq2 TimA	90.6	0	0	3.1	0	3.1	6.3	3.1
	Seq2 TimB	90.6	0	0	0	3.1	3.1	12.5	0
	Seq3 TimA	93.8	0	0	0	0	3.1	9.4	0
	Seq3 TimB	93.8	0	0	0	6.3	6.3	6.2	3.1
Sadness	Seq1	0	93.8	0	3.1	0	0	9.4	0
	Seq2 TimA	0	93.8	0	6.3	0	6.3	6.3	0
	Seq2 TimB	0	100	0	3.2	0	6.5	3.2	0
	Seq3 TimA	0	96.9	0	0	6.3	0	3.1	0
	Seq3 TimB	3.2	93.6	0	6.5	0	9.7	3.2	0
Anger	Seq1	0	3.1	75	3.1	50	6.3	3.1	0
	Seq2 TimA	0	12.5	68.8	3.1	34.4	12.5	12.5	0
	Seq2 TimB	0	3.1	71.9	6.3	31.3	6.3	3.1	0
	Seq3 TimA	0	3.1	62.5	6.3	43.8	12.5	6.3	0
	Seq3 TimB	0	3.1	75	3.1	46.9	15.6	9.4	0
Fear	Seq1	0	3.2	0	100	3.2	25	3.2	0
	Seq2 TimA	0	0	0	90.6	9.4	31.3	3.1	0
	Seq2 TimB	0	12.5	0	93.8	15.6	28.1	0	0
	Seq3 TimA	0	3.2	0	90.3	16.1	25.8	6.5	0
	Seq3 TimB	0	6.3	0	81.3	15.6	28.1	3.1	0
Disgust	Seq1	0	0	25.8	0	87.1	0	0	0
	Seq2 TimA	0	0	25	0	90.6	3.1	3.1	0
	Seq2 TimB	0	0	50	6.3	65.6	3.1	6.3	0
	Seq3 TimA	0	3.1	31.3	0	87.5	0	3.1	0
	Seq3 TimB	0	0	21.9	0	90.6	0	3.1	0
Surprise	Seq1	6.3	0	0	0	0	100	0	0
	Seq2 TimA	3.1	0	0	3.1	0	100	0	0
	Seq2 TimB	0	3.1	0	3.1	0	96.9	0	0
	Seq3 TimA	3.1	0	0	0	0	100	0	0
	Seq3 TimB	0	0	0	0	0	100	3.1	0

animations of anger, disgust was also identified above chance. To assess whether disgust was identified significantly above the chance rate of 25%, the chi-square test was used. For two of the animations, identification of disgust was significantly above chance[1]; in Seq1 ($\chi 2(1) = 10.667$, $p < .002$, $n = 32$) and in Seq3 TimB ($\chi 2(1) = 8.167$, $p < .005$, $n = 32$). This result corresponds with the artistic observations of animating anger (see 4.4.1), specifically, that

[1] Where the critical p value = .01.

expressions of anger should lead with the upper face in order to maximise observer identification of the intended emotion, and that leading with the lower face could result in mixed or complex expressions of emotion . For four animations of disgust, anger was also identified above chance. Of these animations, anger was identified significantly above chance in only one case; Seq2. Tim.B ($\chi^2(1) = 10.667$, $p < .002$, $n = 32$). Again, this corroborates the findings of the practice-based study of disgust animation and the study of observer confusion between disgust and anger, both of which indicated that disgust expressions leading with the upper face would become confused with anger.

5.2.3.4 Perceived authenticity of animated expressions

Participants rated their perceived authenticity of each animation on a 7-point Likert scale of 'not authentic' (1) to 'authentic' (7). Firstly, the data for all of the animations were compiled into a single data set in order to determine whether choreography had an effect on observer rating of authenticity across all animations. The results of a Friedman ANOVA indicated that the selection of EEC did affect observer rating of authenticity irrespective of the emotion being animated: $\chi^2(4) = 34.589$, $p < .001$, $n = 183$. In this case, the simultaneous movement (Seq.1) and upper face leading with overlapped timing (Seq.2 Tim.A) EECs were the most authentic in general, while lower face leading with distinct timing (Seq.3 Tim.B) was the least authentic. Wilcoxon paired comparisons[1] showed that Seq.1 was more authentic than Seq.2 Tim.B ($T = 6094$, $r = -0.19$, $n = 188$, $p < .01$), and Seq.3

[1] Where the critical p value = .01.

Tim.B (T = 7052, r = -0.38, n = 188 p < .001). Additionally, Seq.3 Tim.B was less authentic than Seq.2 Tim.A (T = 6493, r = -0.40, n = 189 p < .001), Seq.2 Tim.B (T = 6510, r = -0.24, n = 188, p < .002), and Seq.3 Tim.A (T = 5765 r = -0.26, n = 188, p < .001). The effect of EEC on each of the individual emotional expressions was then tested. Table 5.4 shows the mean authenticity rating for each of the thirty emotional expression animations. The Friedman test was selected to rank each of the emotional expression choreographies for each emotional expression. The results of the Friedman test for each emotional expression are also shown in Table 5.4.

Table 5.4: Mean authenticity ratings (on a scale of 1-7, where 1 is 'not authentic' and 7 is 'authentic'), Friedman test mean ranks, and Friedman test results for each emotional expression animation.

Emotion	Friedman test Critical p value = .05	Mean Rank	EEC ranked least most authentic	Mean Rating
Happiness	$\chi^2(4) = 2.862$, $p < .582$, $n = 30$	2.75	Seq2 TimB	4.17
		2.85	Seq1	4.57
		2.98	Seq2 TimA	4.50
		3.18	Seq3 TimB	4.80
		3.23	Seq3 TimA	4.63
Sadness	$\chi^2(4) = 14.108$, <u>**$p < .008$**</u>, $n = 30$	2.18	Seq3 TimB	4.17
		2.97	Seq3 TimA	5.03
		3.25	Seq1	5.50
		3.28	Seq2 TimB	5.33
		3.32	Seq2 TimA	5.33
Anger	$\chi^2(4) = 12.871$, <u>**$p < .013$**</u>, $n = 29$	2.31	Seq3 TimB	4.17
		2.81	Seq1	4.69
		3.03	Seq2 TimA	4.86
		3.33	Seq3 TimA	4.93
		3.52	Seq2 TimB	5.31
Fear	$\chi^2(4) = 25.004$, <u>**$p < .001$**</u>, $n = 31$	2.52	Seq2 TimB	4.48
		2.55	Seq3 TimB	4.74
		2.56	Seq3 TimA	4.55
		3.68	Seq2 TimA	5.81
		3.69	Seq1	5.68
Disgust	$\chi^2(4) = 6.515$, $p < .165$, $n = 32$	2.59	Seq3 TimB	4.09
		2.83	Seq2 TimA	4.41
		2.98	Seq3 TimA	4.59
		3.14	Seq1	4.91
		3.45	Seq2 TimB	5.00
Surprise	$\chi^2(4) = 23.974$, <u>**$p < .001$**</u>, $n = 31$	2.10	Seq3 TimB	3.81
		2.81	Seq2 TimB	4.58
		3.06	Seq3 TimA	5.10
		3.40	Seq2 TimA	5.52
		3.63	Seq1	5.77

As shown in Table 5.4, for four of the emotional expressions, the differences between EEC ratings were found to be significant; sadness ($\chi^2(4) = 14.108$, $p < .008$, $n = 30$), anger ($\chi^2(4) = 12.871$, $p < .013$, $n = 29$), fear ($\chi^2(4) = 25.004$, $p < .001$, $n = 31$) and surprise ($\chi^2(4) = 23.974$, $p < .001$, $n = 31$). For happiness ($\chi^2(4) = 2.862$, $p < .582$, $n = 30$) and disgust ($\chi^2(4) = 6.515$, $p < .165$, $n = 32$), the differences between EEC ratings were non-significant. Figure 5.5 shows the mean authenticity ratings for each choreographed emotional expression animation. To identify where significant differences between these ratings lay, the Wilcoxon signed ranks test was used with pairs of emotional expression choreographies. A Bonferroni correction was applied to the critical p value, resulting in a value of $p = .01$.

For sadness, the Wilcoxon signed ranks test showed that lower face leading with distinct timing (Seq.3 Tim.B) was significantly less authentic than; Seq.1 ($T = 39.5$, $r = -0.521$, $p < .005$), Seq.2 Tim.A ($T = 36.5$, $r = -0.627$, $p < .002$), and Seq.2 Tim.B ($T = 70$, $r = -0.527$, $p < .005$). In other words, observers perceived sadness animations to be more authentic when the upper face was involved in the initial movement, either as a simultaneous movement with the lower face (Seq.1), or leading the lower face with overlapped (Seq.2 Tim.A) or distinct (Seq.2 Tim.B) timing. For anger, only one paired comparison yielded a significant result; Seq.3 Tim.B was perceived as less authentic than Seq.2 Tim.B ($T = 43$, $r = -0.537$, $p < .004$). In this case, distinct timing was shown to significantly alter observer perception, by making anger animation seem either more authentic when the upper face led (Seq.2 Tim.B) or less authentic when the lower face led (Seq.3 Tim.B).

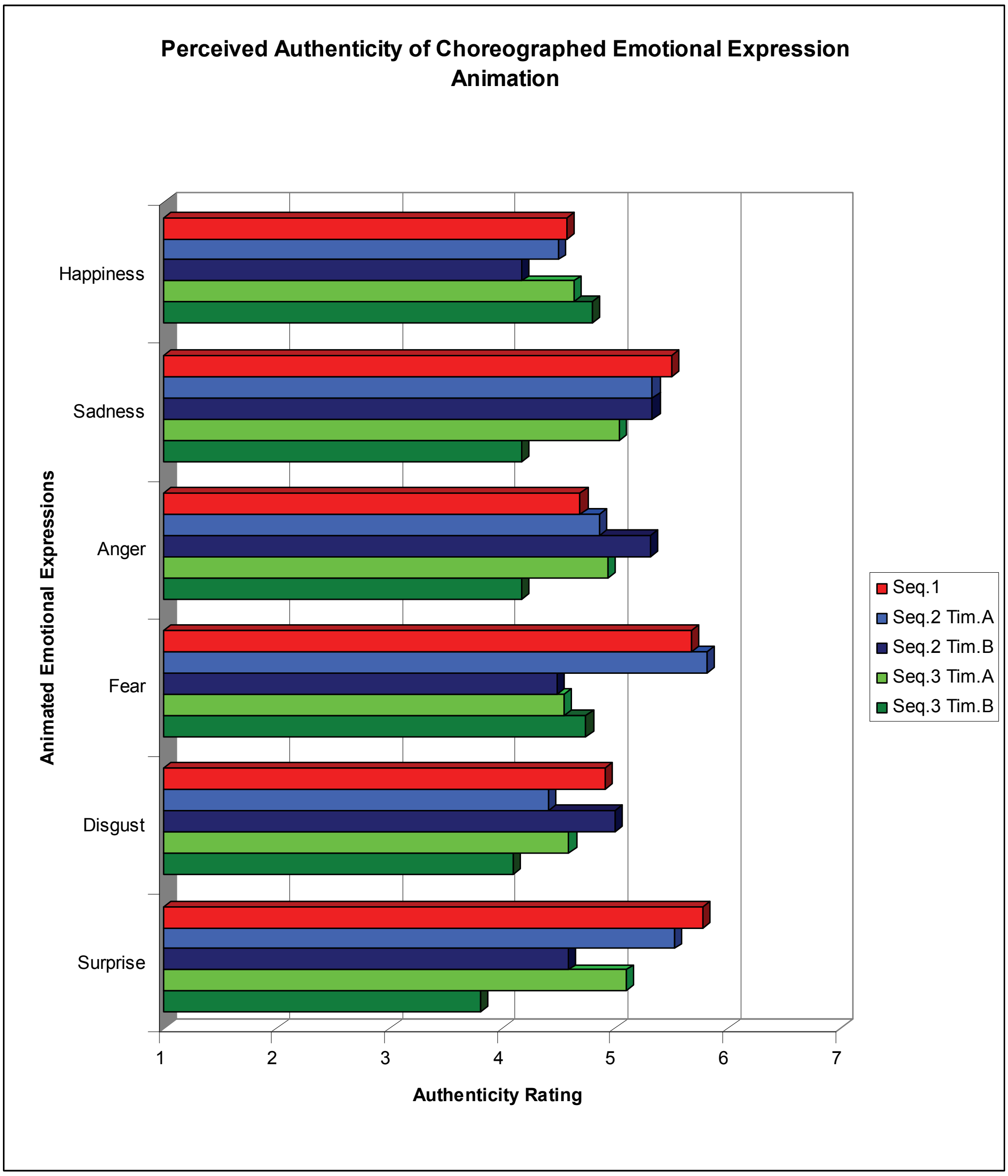


Figure 5.5: Mean authenticity ratings for each emotional expression. A rating of 1 indicates an inauthentic animation and a rating of 7 indicates an authentic animation.

For fear, the differences in mean rankings between several of the paired comparisons were significant. Simultaneous movement (Seq.1) was shown to be significantly more authentic than Seq.2 Tim.B (T = 43, r = -0.567, $p < .003$) and Seq.3 Tim.B (T = 46, r = -0.482, $p < .009$). Upper face leading with overlapped timing (Seq.2 Tim.A) was shown to be significantly more authentic than; Seq.2 Tim.B (T = 18, r = -0.626, p < .002), Seq.3 Tim.A (T = 40, r = -0.550, p < .004) and Seq.3 Tim.B (T = 18, r = -0.631, p < .002). For fear animations, therefore, upper face leading with overlapped timing delivered the animation perceived to be the most authentic overall, while simultaneous movement of upper and lower face regions was more authentic than distinct timing choreographies. Finally, for surprise, simultaneous movement and overlapped timing animations were perceived to be more authentic than lower face leading with distinct timing. Seq.3 Tim.B was significantly less authentic than; Seq.1 (T = 27.5, r = -0.616, p < .002), Seq.2 Tim.A (T = 6.5, r = -0.652, p < .001) and Seq.3 Tim.A (T = 24.5, r = -0.581, p < .002).

5.2.4 Discussion

The predictions of this experiment were that the creative application of EEC would have an effect on observer identification of emotion and perception of authenticity. Furthermore, it was put forth that the observations of the practitioner-researcher after reflective studio-practice (Chapter 4) would indicate which choreographies would prove most effective for each emotional expression animation. The subsequent results supported these predictions to an extent. The experiment yielded a number of significant findings related to the initial research questions, the most prominent finding being that manipulation of EEC had a clear effect on participant rating of authenticity for expressions of sadness, anger, fear, and surprise. In the first instance, this represented a step forward in the development of an experimental design for measuring the perception of nuanced, dynamic expressions. Findings from previous studies were largely inconclusive, indicating that the simpler approach to both EEC and experiment design was essential to generating significant results. Nevertheless, there were still some inconclusive results both in terms of observer identification and perceived authenticity of the choreographed emotional expression animations.

Firstly, the results indicated that EEC actually had relatively little impact on how well observers can identify the intended emotions. In all cases, observers were able to accurately identify the intended emotion well above Ekman's (1994) chance rates. While there was some variation in how well each emotion was identified dependent on the particular use of choreography, the differences between identification rates in most cases were not statistically significant. Only with one example was there significant variation in identification rates based on EEC – observer identification of disgust was significantly decreased when the upper face led with distinct timing. This example corresponded with an observation made by the practitioner-researcher after reflective practice (see 4.4.3), i.e. that disgust would be more difficult to identify if the development of the lower face 'sneer' was delayed. Additionally, there were findings related to the perception of mixed emotions. In most cases, observers were able to identify the intended emotion clearly without confusion with other emotions. However, with animations of anger and disgust, there was a significant degree of overlap. Again, this was predicted by the practitioner-researcher after reflective practice (4.4.3). It was also anticipated by previous experimental results related to the perception of anger and disgust (5.1.4). As expected, the confusion between anger and disgust was related to the sequence of upper and lower face movements.

Anger animations were identified as disgust above chance rates in all cases, but were only identified significantly above chance when there was simultaneous movement, or the lower face led the upper face with either overlapped or distinct timing. In other words, anger was less easily confused with disgust when the upper face moved first. With disgust, the reverse was true, in that only one EEC – upper face leading with distinct timing – resulted in confusion with anger significantly above chance rates. It would therefore be safe to say that emotional expression choreography has a small and often non-significant effect on how well audiences can identify the emotion(s) in facial animation. However, in certain cases (anger and disgust in this study) the effect of EEC on audience identification can be significant and predictable. In answering the first research question – whether creatively-applied emotional expression choreographies affected observer identification of emotion when viewing emotional expression animation – the evidence therefore supports the assertion that choreography can affect observer identification of emotion, but only for specific emotional expressions.

As regards the effect of choreography on observer's perception of authenticity, a greater range of statistically significant findings were present – many of which aligned with the observations of the practitioner-researcher. For just two of the emotional expressions – happiness and disgust – the effects of choreography on observer ratings for perceived authenticity were found to be non-significant. This represented a somewhat unexpected problem, as these two expressions were the ones which were predicted to appear more authentic when the lower face led the movement across the face. A number of potential explanations for this result can be proposed. It could be that observers had a tendency to focus on the eyes (and thus the upper face) when the videos appeared on screen, resulting in a distorted result when lower face leading animations were perceived as more believable than choreographies which started with the upper face. This could be tested in a future study, for instance by using eye tracking technology to determine where observers focus their attention while watching the videos. A second proposal could be that, generally, simultaneous or upper face leading (especially with overlapped timing) choreographies are perceived as being more authentic, and that lower face leading choreographies (especially with distinct timing) are perceived as inauthentic. This conclusion could be supported by the finding that lower face leading the upper face with distinct timing (Seq.3 Tim.B) was perceived as significantly less authentic in general when compared to alternatives, particularly when compared with simultaneous movement (Seq.1) and upper face leading with overlapped timing (Seq.2 Tim.A). However, this idea may be countered by the findings of the next experiment (see 5.3). Alternatively, it may be suggested that observers genuinely could not discriminate between animations of happiness or disgust when different EECs were used. If this were to be the case, then it could be concluded that all choreographies for happiness and disgust are broadly equal in terms of perceived authenticity, and that a simple measure of authenticity may not be sufficient to determine how believable a particular choreography is for these emotions.

For the remaining emotional expressions, EEC was shown to affect perceived authenticity. Sadness animation was significantly more authentic when simultaneous movement or upper face leading the lower face (with either distinct or overlapped timing) was used. This finding aligned with the artistic observation which specifically stated that upper face leading with overlapped timing would appear most believable, and that lower face leading choreographies would break observer's suspension of disbelief. Anger, too, appeared more authentic when it was animated using the choreography predicted to be most effective – upper face leading with distinct timing was significantly more authentic than lower face leading with distinct timing. The two choreographies observed by the practitioner-researcher to generate the most believable animation of fear – simultaneous movement and upper face leading with overlapped timing – were significantly more authentic than a range of alternatives. Finally, the artistic observation that surprise would become less believable as the timing became distinct held true, as simultaneous movement (Seq.1), upper face leading with overlapped timing (Seq.2 Tim.A), and lower face leading with overlapped timing (Seq.3 Tim.A) were all significantly more authentic than lower face leading with distinct timing (Seq.3 Tim.B). Therefore, the evidence supports research hypotheses II and III, in that choreography was not only shown to affect observer authenticity of animated emotional expressions in a range of cases, but also that the observations of the practitioner-researcher aligned with the statistical findings in most instances. Table 5.5 summarizes the artistic predictions regarding the clarity and authenticity of choreographed expressions (developed through performative research) alongside the experimental findings.

Table 5.5: Comparison between the artistic predictions derived from performative research and the findings of the current experiment for each emotional expression. Alignment between predictions and findings are highlighted in yellow.

	Performative Predictions		**Experimental Findings**	
Animation	**Authentic**	**Not Authentic**	**Authentic**	**Not Authentic**
Happiness	**Seq.3 Tim.A**	**Seq.2 Tim.B**	No significant finding	No significant finding
Sadness	**Seq.2 Tim.A**	**Seq.3 Tim.B**	**Seq.1**, **Seq.2 Tim.A** and **Seq.2 Tim.B**	**Seq.3 Tim.B**
Anger	**Seq.2 Tim.A** or **Seq.2 Tim.B**	**Seq.3 Tim.A** or **Seq.3 Tim.B**	**Seq.2 Tim.B**	**Seq.3 Tim.B**
Fear	**Seq.1** or **Seq.2 Tim.A**	**Seq.3 Tim.B**	**Seq.1** and **Seq.2 Tim.A**	**Seq.2 Tim.B**, **Seq.3 Tim.A** and **Seq.3 Tim.B**
Disgust	**Seq.3 Tim.A** or **Seq.3 Tim.B**	No prediction	No significant finding	No significant finding
Surprise	**Seq.1** or **Seq.2 Tim.A**	**Seq.3 Tim.B**	**Seq.1**, **Seq.2 Tim.A** and **Seq.3 Tim.A**	**Seq.3 Tim.B**

By testing the research hypotheses, the findings of this experiment suggest that EEC - when creatively-applied to facial animation - can affect both the identification and perceived authenticity of emotional expression animations. In most cases, artistic predictions can be translated into significant experimental results. However, the differences between identification rates and authenticity ratings are generally quite small. Nevertheless, they lend weight to the more detailed findings of the performative research methods, and could be further explored using qualitative approaches to EEC production and perception (discussed in Chapter 6).

5.3 Experiment 2: observer perception of choreographed expression transitions

The final experiment was designed as a direct follow up to the experiment described in 5.2, taking on the same overall design but incorporating a different range of stimuli videos. As before, the simplified EEC concept (the sequence and timing of upper and lower facial regions, see 4.3.1) was used as a framework for the artistic production of facial animation. However, for this experiment, emotional expression transitions (the animation of one emotional expression into another) were selected for investigation, in contrast to the individual emotional expression onsets that were assessed in the previous experiment. A range of emotional expression transitions were animated using the performative methodology (see 4.5), with detailed artistic observations and predictions made after structured reflection (4.5.3). Experiment 2 was designed as a means to assess audience perception of these choreographed transition animations, in order to determine whether EEC affected how observers interpreted transitions, and to ascertain whether the artistic observations were accurate predictions for tests of observer perception. The results of this experiment were initially reported in Sloan et al. (2010b).

5.3.1 Research questions

The overarching research question for this experiment was, as before, whether EEC could affect observer perception of animated expressions. Like the previous experiment, this experiment was concerned with the perception of artistically produced animations, which were developed according to the five-level emotional expression choreography framework. The research questions were as follows:

I. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect observer identification of the first and last emotions when viewing emotional expression transition animations?

II. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect the perceived authenticity of emotional expression transition animations?

III. Do the results for observer identification and perceived authenticity of creative emotional expression transition animations align with the artistic observations and predictions of the practitioner-researcher?

It was therefore predicted that the application of choreography to emotional expression transition animations would affect observer identification of emotion, perceived authenticity of expressions, and also that the experimental findings would corroborate the observations of the practitioner-researcher.

5.3.2 Experiment design

The purpose of this final experiment was to assess observer perception of the thirty videos produced as a result of animation study 2 (discussed in 4.5). These videos depicted six emotional expression transitions ('happiness into sadness', 'sadness into anger', 'anger into fear', 'fear into disgust', 'disgust into surprise', and 'surprise into happiness'), which were produced artistically using the five pre-determined emotional expression choreographies as a framework. The five choreographies used were the same as in experiment 1; upper and lower face regions move together (Seq.1), upper face region leads lower face region with overlapped timing (Seq.2 Tim.A), upper face region leads lower face region with distinct timing (Seq.2 Tim.B), lower face region leads upper face region with overlapped timing (Seq.3 Tim.A), and lower face region leads upper face region with distinct timing (Seq.3 Tim.B).

5.3.2.1 Participants

Participants were a mixture of students, academic staff, and support staff of the University of Abertay, as well as members of the public not affiliated with the university. No participants from the previous experiment took part in the current experiment. Thirty-three people (17 female, 16 male) participated in the experiment. Participants were split two groups; group 1 (16 participants, 8 female, 8 male) and group 2 (17 participants, 9 female, 8 male).

5.3.2.2 Materials

Few changes were made to measurements or data collection methods from experiment 2. Observer perception was assessed using the same two measurements; observer identification of emotion, and perceived authenticity of the animated expressions. To account for the presence of two intended emotional expressions in each animation, observer identification of emotion was split into two categories; identification of the first expression, and identification of the last expression. To take these measurements, participants watched all thirty videos twice over two blocks (blocks A and B) and answered questions after each observation. In block A, participants were asked to identify the emotion(s) present in the video which they had just observed. Participants were able to select one or multiple from the following options; ‘happiness’, ‘sadness’, ‘anger’, ‘fear’, ‘disgust’, ‘surprise’, ‘other emotion’, ‘no emotion’, and ‘don’t know’. Participants selected a minimum of one option for both the identification of the first expression and the identification of the last expression. In block B, participants were asked to rate how authentic they thought the overall emotional expression animation was, using a 7-point Likert scale from ‘not authentic’ to ‘authentic’. Participants were told to consider an animation that looked unbelievable, unnatural, or unrealistic as being ‘not authentic’, whereas an animation that looked believable, natural, or realistic should be considered ‘authentic’. Participants were instructed to pay particular attention to the change of expression, and to rate how authentic they thought the animation was based on the transition rather than the appearance of the first or last expression. The researcher encouraged all participants to use the full scale if they were confident that the transition was authentic or inauthentic. Participants were also given the option of clicking a button labelled 'I missed the clip' after a video finished playing, which they were told to use if they were distracted while viewing the video. As before, this option skipped the current video all together, meaning that the participant did not submit any data for the video. In order to avoid missing data (which caused some problems in the analysis of experiment 1), participants were reminded that they were in control of the pace of the experiment, that they should only use the 'I missed the clip' option if they missed the video completely, and that they should use the 'don't know' option if they weren't sure what the expression in the video was (rather than selecting 'I missed the clip').

The experiment took place in a private room of the White Space research centre at the University of Abertay. The participants – who sat in isolation for the duration of the experiment – watched all thirty videos twice, displayed at a resolution of 720x576 on a 1680x1050 screen.

5.3.2.3 Procedure

As before, videos were shown to participants twice over two blocks. Participants were split into two groups (1 and 2). Group 1 participants completed block A followed by block B, while group 2 participants completed block B followed by block A. The statistical tests used for data analysis in experiment 1 were selected for analysis of the data of the current experiment. The Mann-Whitney test was used to determine whether participant sex or participant group affected observer perception (section 5.3.3.1). To assess observer identification of the intended emotion (5.3.3.2) and other emotions (5.3.3.3) where choreography was the main variable, chi-square tests and Wilcoxon signed ranks tests were used. Finally, to determine whether emotional expression choreography affected the perceived authenticity of expression transitions, Friedman tests and Wilcoxon signed ranks tests were used (5.3.3.4).

5.3.3 Results

5.3.3.1 Testing for effects of confounding variables

The Mann-Whitney test was used to ascertain whether participant sex or question order (participant group) had an effect on participant identification or rating of animations. Participant identification data for all thirty videos was compiled into a single data set. The critical p value was corrected for the number of tests (n = 30) resulting in a p value of .0017. The first test demonstrated that there were no statistically significant effects of participant sex ($p > .259$) or participant group ($p > .063$) on identification of emotion. To determine whether participant sex or participant group affected observer perception of expression authenticity, the ratings for all 30 videos were compiled and the critical p value again corrected to .0017 to account for the number of tests. The Mann-Whitney test results showed that neither participant sex ($p > .732$) nor participant group ($p > .082$) had a significant effect on observer rating of authenticity. As neither participant sex nor question order had a significant effect on either identification of emotion or rating of authenticity, further analysis was conducted to assess whether the use of EEC affected how observers interpreted expression transition animation.

5.3.3.2 Identification of intended emotions

As with the previous experiment, the first goal when assessing audience identification of transition animations was to determine whether participants correctly identified the intended first and second emotion in all expression transition animations, and to then determine whether EEC affected identification of these emotions. Again, chance identification rates suggested by Ekman (1994) were adopted as the baseline; 50% for happiness, 33% for surprise, and 25% for sadness, anger, fear and disgust.

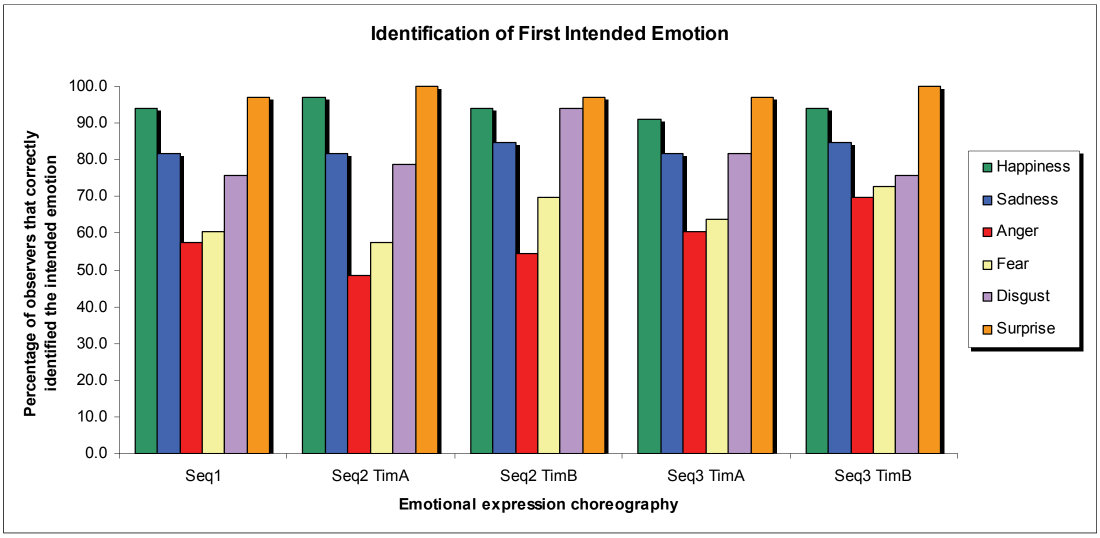


Figure 5.6: Identification rates (%) for the first intended emotion in all thirty expression transition animations.

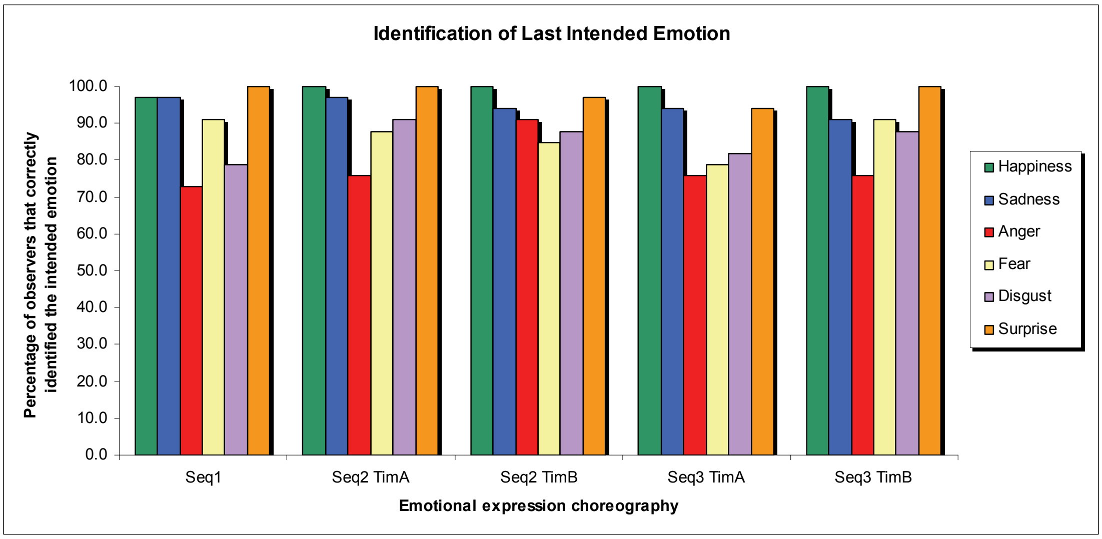


Figure 5.7: Identification rates (%) for the second intended emotion in all thirty expression transition animations.

As shown in Figures 5.6 and 5.7, the intended emotions were identified above the respective chance rates irrespective of emotional expression choreography. Figure 5.6 shows the identification rates for each emotion when it was the first emotional expression in the animation. Figure 5.7 shows the identification rates for each emotion when said emotion was the second intended expression in the animation. To test whether the identification rates were significantly above Ekman's (1994) chance rates, the chi-square test was used to compare the observed number of correct identifications to the expected number of identifications according to the chance rates. For all emotions (both first and second in the transition) and all emotional expression choreographies, the intended emotion was identified significantly above chance[1]. Table 5.6 shows the results of the chi-square tests for identification of the first intended emotion in each animation, while Table 5.7 shows the chi-

[1] Where the critical p value was corrected for the number of tests, resulting in a p value of .0017.

square results for identification of the second intended emotional expression in each animation.

Table 5.6: Results of chi-square tests comparing identification of the first intended emotion (Observed *n*) to Ekman's chance rates (Expected *n*) in each expression transition animation.

Animation	First Emo.	EEC	Chi-Square results	Exp. n	Obs. n
Hap>Sad	Hap.	Seq1	$\chi^2(1) = 25.385$, $p < .001$, $n = 33$	16.5	31
		Seq2 TimA	$\chi^2(1) = 29.121$, $p < .001$, $n = 33$	16.5	32
		Seq2 TimB	$\chi^2(1) = 25.485$, $p < .001$, $n = 33$	16.5	31
		Seq3 TimA	$\chi^2(1) = 22.091$, $p < .001$, $n = 33$	16.5	30
		Seq3 TimB	$\chi^2(1) = 25.485$, $p < .001$, $n = 33$	16.5	31
Sad>Ang	Sad.	Seq1	$\chi^2(1) = 56.818$, $p < .001$, $n = 33$	8.3	27
		Seq2 TimA	$\chi^2(1) = 56.818$, $p < .001$, $n = 33$	8.3	27
		Seq2 TimB	$\chi^2(1) = 63.040$, $p < .001$, $n = 33$	8.3	28
		Seq3 TimA	$\chi^2(1) = 56.818$, $p < .001$, $n = 33$	8.3	27
		Seq3 TimB	$\chi^2(1) = 63.040$, $p < .001$, $n = 33$	8.3	28
Ang>Fea	Ang.	Seq1	$\chi^2(1) = 18.677$, $p < .001$, $n = 33$	8.3	19
		Seq2 TimA	$\chi^2(1) = 9.707$, $p < .001$, $n = 33$	8.3	16
		Seq2 TimB	$\chi^2(1) = 15.364$, $p < .001$, $n = 33$	8.3	18
		Seq3 TimA	$\chi^2(1) = 22.313$, $p < .001$, $n = 33$	8.3	20
		Seq3 TimB	$\chi^2(1) = 35.162$, $p < .001$, $n = 33$	8.3	23
Fea>Dis	Fea.	Seq1	$\chi^2(1) = 22.313$, $p < .001$, $n = 33$	8.3	20
		Seq2 TimA	$\chi^2(1) = 18.677$, $p < .001$, $n = 33$	8.3	19
		Seq2 TimB	$\chi^2(1) = 35.162$, $p < .001$, $n = 33$	8.3	23
		Seq3 TimA	$\chi^2(1) = 26.273$, $p < .001$, $n = 33$	8.3	21
		Seq3 TimB	$\chi^2(1) = 40.091$, $p < .001$, $n = 33$	8.3	24
Dis>Sur	Dis.	Seq1	$\chi^2(1) = 45.343$, $p < .001$, $n = 33$	8.3	25
		Seq2 TimA	$\chi^2(1) = 50.919$, $p < .001$, $n = 33$	8.3	26
		Seq2 TimB	$\chi^2(1) = 83.646$, $p < .001$, $n = 33$	8.3	31
		Seq3 TimA	$\chi^2(1) = 56.818$, $p < .001$, $n = 33$	8.3	27
		Seq3 TimB	$\chi^2(1) = 45.343$, $p < .001$, $n = 33$	8.3	25
Sur>Hap	Sur.	Seq1	$\chi^2(1) = 60.146$, $p < .001$, $n = 33$	11	32
		Seq2 TimA	$\chi^2(1) = 66.000$, $p < .001$, $n = 33$	11	33
		Seq2 TimB	$\chi^2(1) = 60.146$, $p < .001$, $n = 33$	11	32
		Seq3 TimA	$\chi^2(1) = 60.146$, $p < .001$, $n = 33$	11	32
		Seq3 TimB	$\chi^2(1) = 66.000$, $p < .001$, $n = 33$	11	33

Table 5.7: Results of chi-square tests comparing identification of the second intended emotion (Observed *n*) to Ekman's chance rates (Expected *n*) in each expression transition animation.

Animation	First Emo.	EEC	Chi-Square results	Exp. n	Obs. n
Hap>Sad	Sad.	Seq1	$\chi^2(1) = 91.162$, $p < .001$, $n = 33$	8.3	32
		Seq2 TimA	$\chi^2(1) = 91.162$, $p < .001$, $n = 33$	8.3	32
		Seq2 TimB	$\chi^2(1) = 83.646$, $p < .001$, $n = 33$	8.3	31
		Seq3 TimA	$\chi^2(1) = 83.646$, $p < .001$, $n = 33$	8.3	31
		Seq3 TimB	$\chi^2(1) = 76.455$, $p < .001$, $n = 33$	8.3	30
Sad>Ang	Ang.	Seq1	$\chi^2(1) = 40.091$, $p < .001$, $n = 33$	8.3	24
		Seq2 TimA	$\chi^2(1) = 45.343$, $p < .001$, $n = 33$	8.3	25
		Seq2 TimB	$\chi^2(1) = 76.455$, $p < .001$, $n = 33$	8.3	30
		Seq3 TimA	$\chi^2(1) = 45.343$, $p < .001$, $n = 33$	8.3	25
		Seq3 TimB	$\chi^2(1) = 45.343$, $p < .001$, $n = 33$	8.3	25
Ang>Fea	Fea.	Seq1	$\chi^2(1) = 76.455$, $p < .001$, $n = 33$	8.3	30
		Seq2 TimA	$\chi^2(1) = 69.586$, $p < .001$, $n = 33$	8.3	29
		Seq2 TimB	$\chi^2(1) = 63.040$, $p < .001$, $n = 33$	8.3	28
		Seq3 TimA	$\chi^2(1) = 50.919$, $p < .001$, $n = 33$	8.3	26
		Seq3 TimB	$\chi^2(1) = 76.455$, $p < .001$, $n = 33$	8.3	30
Fea>Dis	Dis.	Seq1	$\chi^2(1) = 50.919$, $p < .001$, $n = 33$	8.3	26
		Seq2 TimA	$\chi^2(1) = 76.455$, $p < .001$, $n = 33$	8.3	30
		Seq2 TimB	$\chi^2(1) = 69.586$, $p < .001$, $n = 33$	8.3	29
		Seq3 TimA	$\chi^2(1) = 56.818$, $p < .001$, $n = 33$	8.3	27
		Seq3 TimB	$\chi^2(1) = 69.586$, $p < .001$, $n = 33$	8.3	29
Dis>Sur	Sur.	Seq1	$\chi^2(1) = 66.000$, $p < .001$, $n = 33$	11	33
		Seq2 TimA	$\chi^2(1) = 66.000$, $p < .001$, $n = 33$	11	33
		Seq2 TimB	$\chi^2(1) = 60.146$, $p < .001$, $n = 33$	11	32
		Seq3 TimA	$\chi^2(1) = 54.554$, $p < .001$, $n = 33$	11	31
		Seq3 TimB	$\chi^2(1) = 66.000$, $p < .001$, $n = 33$	11	33
Sur>Hap	Hap.	Seq1	$\chi^2(1) = 29.121$, $p < .001$, $n = 33$	16.5	32
		Seq2 TimA	$\chi^2(1) = 33.000$, $p < .001$, $n = 33$	16.5	33
		Seq2 TimB	$\chi^2(1) = 33.000$, $p < .001$, $n = 33$	16.5	33
		Seq3 TimA	$\chi^2(1) = 33.000$, $p < .001$, $n = 33$	16.5	33
		Seq3 TimB	$\chi^2(1) = 33.000$, $p < .001$, $n = 33$	16.5	33

As with the previous experiment, these findings support the idea that any of the five EECs can be used to successfully animate any of the six emotional expression transitions which were tested, since observers should be able to identify the intended first and last emotional expressions well above chance rates. However, as shown in Figures 5.6 and 5.7, there was once again a degree of variation in how well particular emotional expressions were identified when different EECs were used. As before, identification rates for happiness, sadness, and surprise were broadly equal regardless of choreography (the greatest difference between a pair of choreographies was < 10%) but there were larger differences between pairs of choreographies for anger, fear and disgust (summarised in Figures 5.8-5.12). Firstly, for animations of 'sadness into anger', anger was more readily identified as the second emotional expression in Seq.2 Tim.B when compared to alternate choreographies; Seq.1, Seq.2 Tim.A, Seq.3 Tim.A, and Seq.3 Tim.B. This would suggest that expressions of anger that emerge from expressions of sadness are easiest to identify when the upper face leads with distinct timing. For animations of 'anger into fear', anger was more clearly identified as the first emotional expression in Seq.3 Tim.B than in Seq.1, Seq.2 Tim.A, and Seq.2 Tim.B (54.5%), indicating once again that anger is more easily identified when it is expressed and held in the upper face. In the same animations of 'anger into fear', fear was identified as the second emotion more frequently in Seq.1 and Seq.3 Tim.B than in Seq.3 Tim.A. For animations of 'fear into disgust', fear was less well identified as the first emotional expression by observers in Seq.1 and Seq.2 Tim.A than in Seq.2 Tim.B and Seq.3 Tim.B. This would suggest that fear is easier to identify in the transition 'fear into disgust' when either the upper or lower face leads with distinct timing, with overlapped timing and simultaneous movement resulting in more difficult to read expressions of fear. In the same animations of 'fear into disgust', disgust was identified as the last emotion more readily in Seq.2 Tim.A than in Seq.1. Finally, for animations of 'disgust into surprise', disgust was most frequently identified as the first emotion in Seq.2 Tim.B while the emotion was less well identified in Seq.1, Seq.2 Tim.A, Seq.3 Tim.A and

Seq.3 Tim.B. In this case, disgust was identified more easily by observers when the lower face expression (the sneer) was held for as long as possible.

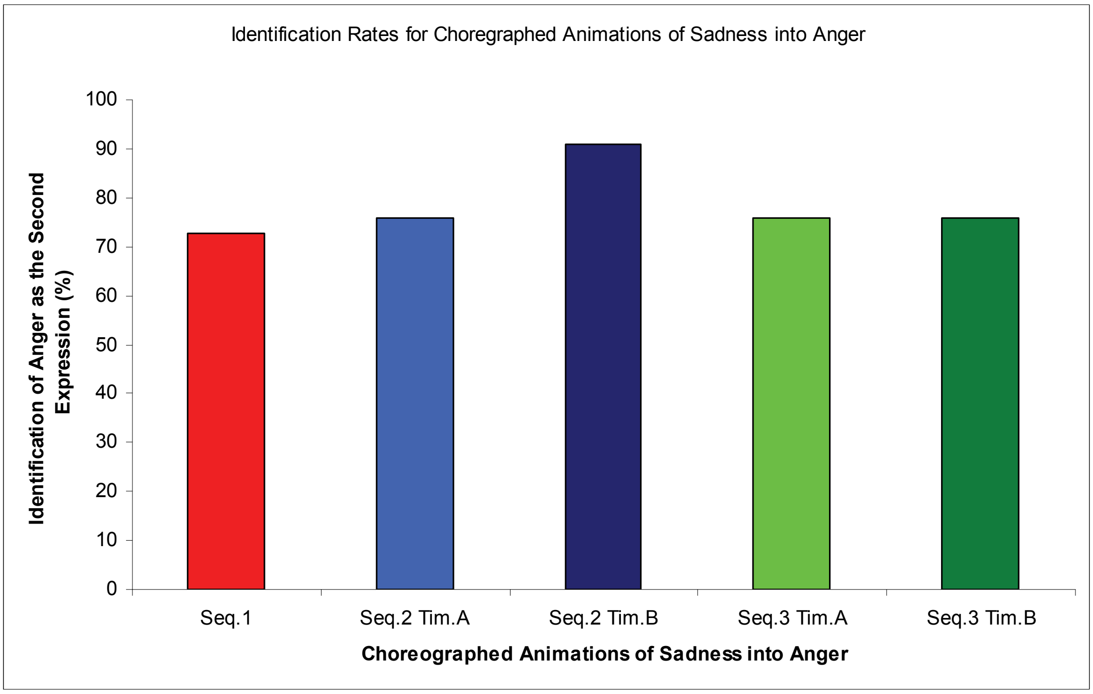


Figure 5.8: Identification rates for anger in 'sadness into anger' animations.

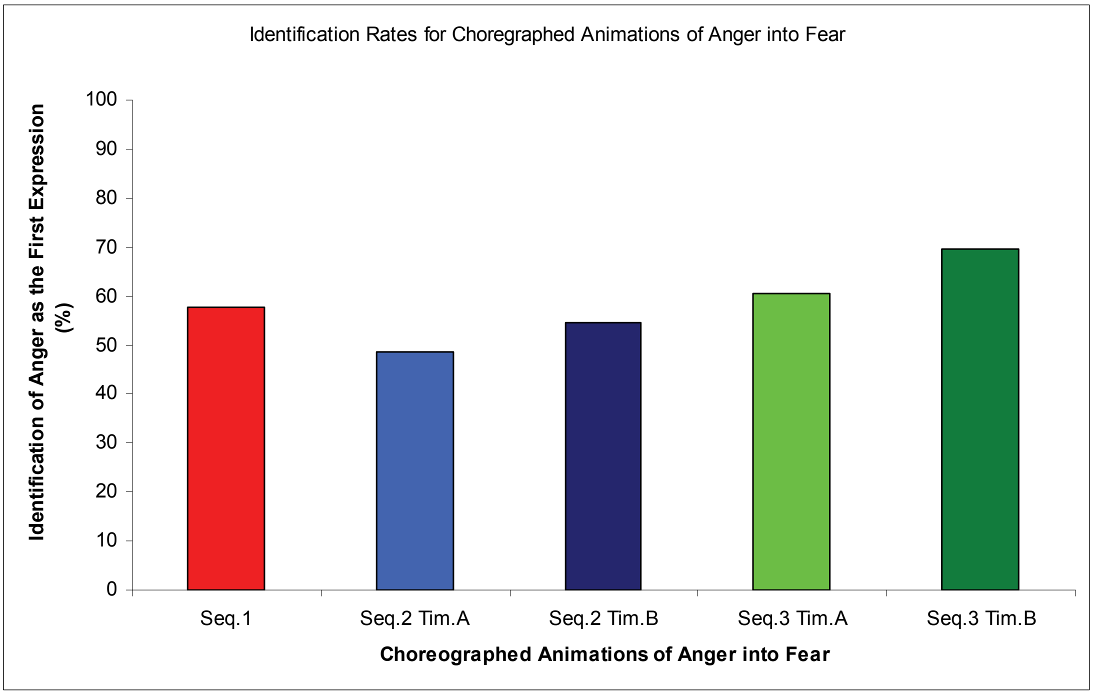


Figure 5.9: Identification rates for anger in 'anger into fear' animations.

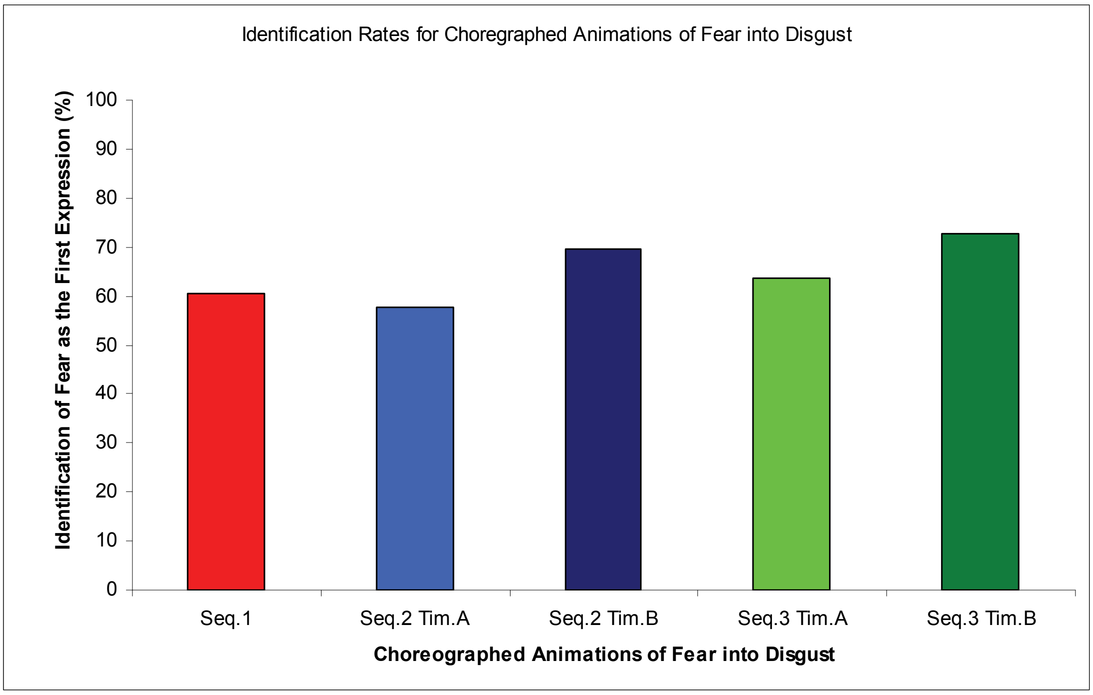


Figure 5.10: Identification rates for fear in 'fear into disgust' animations.

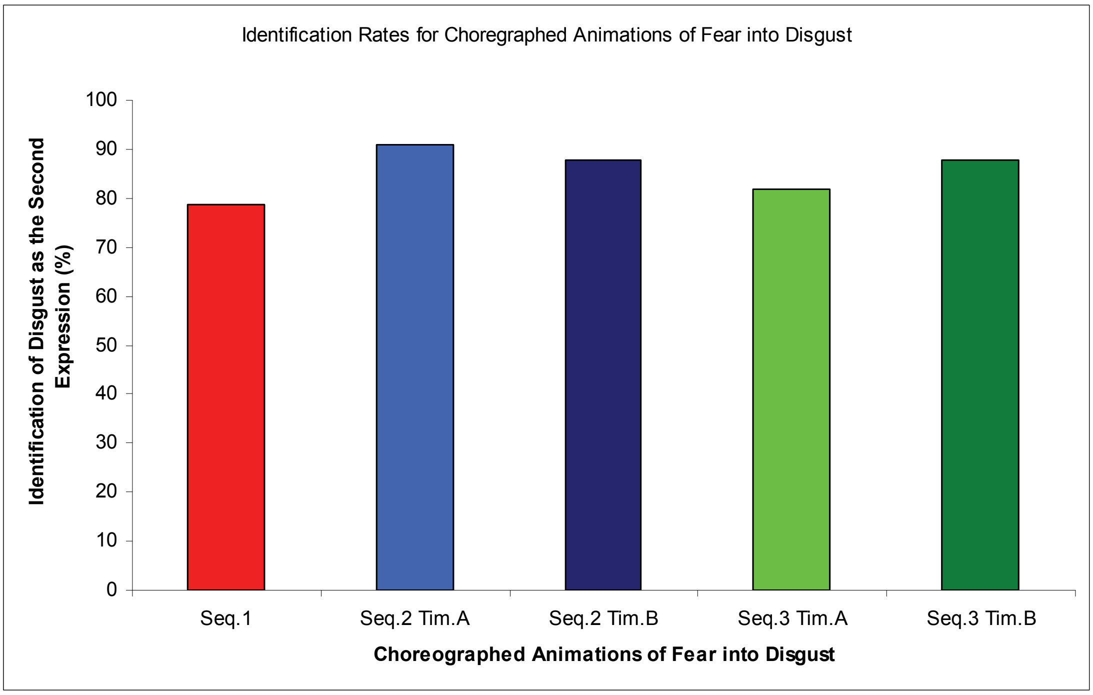


Figure 5.11: Identification rates for disgust in 'fear into disgust' animations.

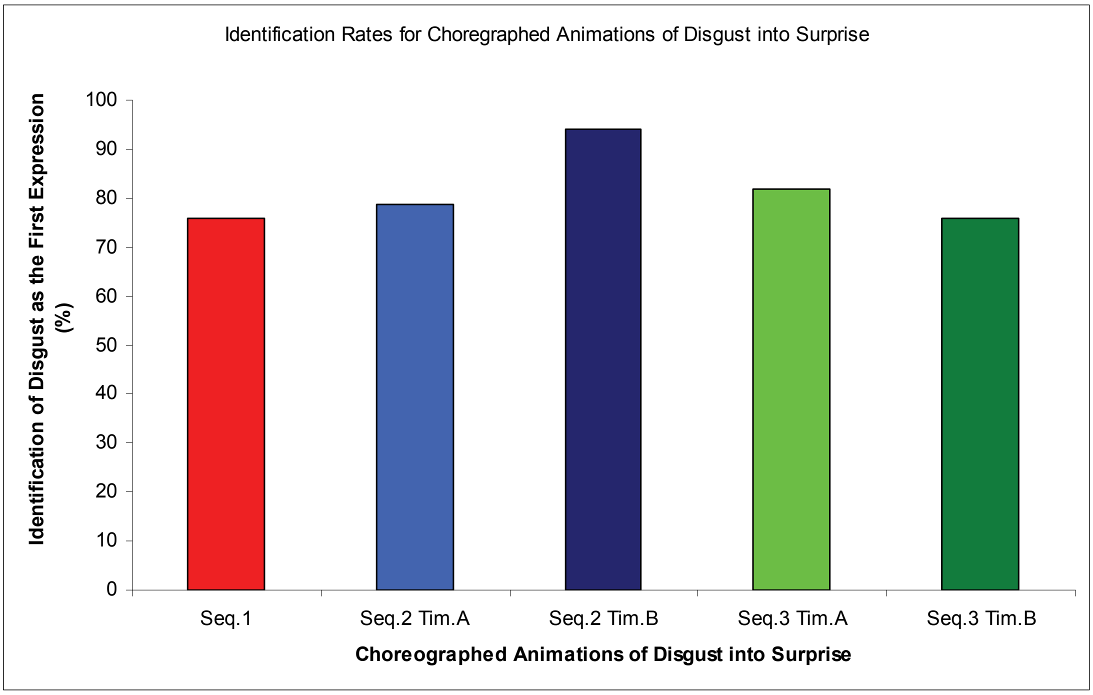


Figure 5.12: Identification rates for disgust in 'disgust into surprise' animations.

As with the previous experiment, these differences roughly corroborated some of the predictions that resulted from iterative artistic practice and reflection (see 4.5.3). It was observed in the performative phase that anger emerging from sadness would be most clearly presented to the audience if the upper face led the transition . This was apparent in the results of this experiment, with Seq.2 Tim.B (upper face leading with distinct timing) producing the highest identification rates for anger as a secondary expression. When anger was the first expression (as part of the 'anger into fear' animation), it was predicted that lower face leading would produce a more recognizable expression of anger. Again, the results of this experiment indicated that this was indeed the case. On the other hand, it was observed in the performative research that Seq.3 Tim.A and Tim.B for 'anger into fear' could create confusing expressions of fear, and that alternative choreographies (specifically Seq.1 or Seq.2 Tim.A) might present an expression of fear that is easier to identify. The experimental results indicated that Seq.1 was indeed a more effective EEC when it came to conveying a clear expression of fear, and that Seq.3 Tim.A was relatively poor. For the transition ‘fear into disgust’, the results indicated that distinct timing (essentially holding either the wide eyes or wide mouth of fear while disgust begins to appear) created the most clear expressions of fear. This result was at least partially predicted by the practitioner-researcher, who observed that Seq.3 Tim.B would enhance the expression of fear. There was little difference between identification rates of disgust as the secondary emotion in these transitions, however. Finally, for animation of ‘disgust into surprise’, the choreography that produced the most recognizable expression of disgust was Seq.2 Tim.B – holding the lower face sneer, as predicted by the results of the practice-based study.

However, it was essential to assess whether these differences were statistically significant. The chi-square test was used to compare the results, with a Bonferroni correction applied to account for the number of tests (p = .01). In each chi-square test, the expected n was set at the identification rate for the least well identified choreography in the comparison. The results of the chi-square tests are summarised in Table 5.8. In all cases, the chi-square indicated that the differences between identification rates was non-significant, although in a few cases the p value was close to the critical value of .01 – notably; sadness into anger, anger into fear, and disgust into surprise (see Table 5.8). As concluded previously, the knowledge that choosing a particular choreography over another could result in more than 10% of the audience

Table 5.8: Chi-square results for comparisons between intended emotion identification rates for expression transitions. EEC 1 was the least well identified in each comparison, while EEC 2 was correctly identified by at least 10% more participants. Expected *n* is derived from the identification rate of EEC 1, while Observed *n* is the number of correct identifications for EEC 2. Critical *p* value = .01.

Animation	Choreographies Compared		Chi-Square result	Expected *n*	Observed *n*
	EEC 1	EEC 2			
Sadness into **Anger**	Seq.1	Seq.2 Tim.B	$\chi^2(1) = 5.499$, $p < .02$, $n = 33$	24	30
Anger into Fear	Seq.2 Tim.A	Seq.3 Tim.B	$\chi^2(1) = 5.948$, $p < .016$, $n = 33$	16	23
Fear into Disgust	Seq.2 Tim.A	Seq.3 Tim.B	$\chi^2(1) = 3.092$, $p < .08$, $n = 33$	19	24
Fear into **Disgust**	Seq.1	Seq.2 Tim.A	$\chi^2(1) = 2.9$, $p < .09$, $n = 33$	26	29
Disgust into Surprise	Seq.1 and Seq.3 Tim.B	Seq.2 Tim.B	$\chi^2(1) = 5.939$, $p < .016$, $n = 33$	25	31

being unable to identify the intended emotions is useful in practice, but again this seemed to be difficult to prove statistically. In all comparisons, the differences between identification rates for both the first and last emotional expression were non-significant. Nevertheless, the results for identification of the intended emotion backup the findings of the previous experiment in that, while there certainly appears to be variation in how easily an emotion can be identified when the choreography is manipulated, the differences could be too subtle to prove using statistical methods.

5.3.3.3 Identification of other emotions

The approach adopted in the previous experiment for assessing observer identification of other emotions was replicated for the current experiment. Participants had the ability to select multiple options when they were asked to identify the emotion in each animation, and as a result were able to declare their observation of mixed or other (non-intended) emotions within the animations. Table 5.9 shows the identification rates (%) for each emotion identification option when observers were asked to identify the first expression in the animation, while Table 5.10 shows the identification rates for each option when observers were asked to identify the last expression in the animation.

Table 5.9: Emotion identification rates (%) for the first emotional expression in each transition animation. Identification of; happiness, sadness, anger, fear, disgust, surprise, other emotion, and no emotion. Intended emotion identification rates are highlighted in green. Other (non-intended) emotions that were identified above chance rates are highlighted in yellow.

Animation	EEC	Hap	Sad	Ang	Fea	Dis	Sur	Oth	No
Hap>Sad	Seq1	93.9	0.0	3.0	0.0	0.0	3.0	6.1	3.0
	Seq2 TimA	97.0	0.0	0.0	0.0	0.0	3.0	6.1	0.0
	Seq2 TimB	93.9	0.0	0.0	0.0	0.0	3.0	6.1	0.0
	Seq3 TimA	90.9	3.0	0.0	0.0	0.0	3.0	6.1	0.0
	Seq3 TimB	93.9	0.0	0.0	0.0	0.0	3.0	3.0	0.0
Sad>Ang	Seq1	0.0	81.8	0.0	0.0	3.0	3.0	6.1	6.1
	Seq2 TimA	0.0	81.8	0.0	0.0	3.0	9.1	12.1	0.0
	Seq2 TimB	3.0	84.8	3.0	0.0	3.0	0.0	9.1	6.1
	Seq3 TimA	3.0	81.8	0.0	3.0	3.0	6.1	3.0	6.1
	Seq3 TimB	0.0	84.8	0.0	0.0	6.1	6.1	9.1	3.0
Ang>Fea	Seq1	0.0	6.1	57.6	3.0	12.1	6.1	18.2	9.1
	Seq2 TimA	3.0	3.0	48.5	3.0	24.2	9.1	6.1	6.1
	Seq2 TimB	0.0	0.0	54.5	6.1	15.2	9.1	15.2	6.1
	Seq3 TimA	0.0	6.1	60.6	6.1	12.1	3.0	12.1	6.1
	Seq3 TimB	0.0	6.1	69.7	0.0	21.2	12.1	3.0	0.0
Fea>Dis	Seq1	0.0	3.0	3.0	60.6	6.1	33.3	9.1	0.0
	Seq2 TimA	0.0	6.1	0.0	57.6	9.1	39.4	9.1	3.0
	Seq2 TimB	0.0	6.1	3.0	69.7	9.1	21.2	12.1	3.0
	Seq3 TimA	0.0	12.1	3.0	63.6	9.1	33.3	3.0	3.0
	Seq3 TimB	0.0	3.0	0.0	72.7	12.1	21.2	12.1	0.0
Dis>Sur	Seq1	0.0	3.0	30.3	3.0	75.8	3.0	12.1	0.0
	Seq2 TimA	0.0	3.0	27.3	0.0	78.8	0.0	3.0	3.0
	Seq2 TimB	0.0	0.0	21.2	0.0	93.9	0.0	3.0	0.0
	Seq3 TimA	0.0	3.0	15.2	3.0	81.8	3.0	0.0	0.0
	Seq3 TimB	0.0	0.0	33.3	0.0	75.8	0.0	6.1	0.0
Sur>Hap	Seq1	9.1	0.0	0.0	0.0	0.0	97.0	6.1	0.0
	Seq2 TimA	0.0	0.0	0.0	0.0	0.0	100.0	6.1	3.0
	Seq2 TimB	3.0	0.0	0.0	0.0	0.0	97.0	3.0	0.0
	Seq3 TimA	0.0	0.0	0.0	3.0	0.0	97.0	12.1	0.0
	Seq3 TimB	3.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0

Table 5.10: Emotion identification rates (%) for the second emotional expression in each transition animation. Identification of; happiness, sadness, anger, fear, disgust, surprise, other emotion, and no emotion. Intended emotion identification rates are highlighted in green. Other (non-intended) emotions that were identified above chance rates are highlighted in yellow.

Animation	EEC	Hap	Sad	Ang	Fea	Dis	Sur	Oth	No
Hap>Sad	Seq1	0.0	97.0	0.0	3.0	3.0	0.0	3.0	3.0
	Seq2 TimA	0.0	97.0	0.0	3.0	0.0	0.0	9.1	3.0
	Seq2 TimB	0.0	93.9	0.0	0.0	0.0	3.0	15.2	3.0
	Seq3 TimA	0.0	93.9	0.0	0.0	0.0	3.0	12.1	6.1
	Seq3 TimB	0.0	90.9	0.0	0.0	0.0	0.0	12.1	3.0
Sad>Ang	Seq1	0.0	6.1	72.7	0.0	24.2	3.0	9.1	0.0
	Seq2 TimA	0.0	0.0	75.8	3.0	21.2	6.1	9.1	0.0
	Seq2 TimB	0.0	3.0	90.9	0.0	18.2	0.0	12.1	0.0
	Seq3 TimA	0.0	3.0	75.8	3.0	12.1	3.0	9.1	0.0
	Seq3 TimB	0.0	0.0	75.8	6.1	3.0	9.1	12.1	0.0
Ang>Fea	Seq1	0.0	3.0	0.0	90.9	6.1	9.1	0.0	0.0
	Seq2 TimA	0.0	6.1	0.0	87.9	6.1	15.2	3.0	0.0
	Seq2 TimB	0.0	0.0	0.0	84.8	0.0	24.2	12.1	0.0
	Seq3 TimA	0.0	12.1	3.0	78.8	6.1	21.2	3.0	3.0
	Seq3 TimB	0.0	0.0	6.1	90.9	9.1	15.2	3.0	0.0
Fea>Dis	Seq1	0.0	0.0	24.2	3.0	78.8	0.0	3.0	0.0
	Seq2 TimA	0.0	0.0	24.2	3.0	90.9	0.0	9.1	0.0
	Seq2 TimB	0.0	3.0	21.2	3.0	87.9	0.0	0.0	0.0
	Seq3 TimA	0.0	0.0	30.3	0.0	81.8	0.0	3.0	0.0
	Seq3 TimB	0.0	3.0	24.2	3.0	87.9	0.0	9.1	0.0
Dis>Sur	Seq1	0.0	0.0	0.0	6.1	0.0	100.0	6.1	0.0
	Seq2 TimA	0.0	0.0	0.0	0.0	0.0	100.0	6.1	0.0
	Seq2 TimB	3.0	0.0	0.0	6.1	0.0	97.0	0.0	0.0
	Seq3 TimA	0.0	0.0	0.0	6.1	3.0	93.9	0.0	0.0
	Seq3 TimB	0.0	0.0	0.0	6.1	0.0	100.0	0.0	0.0
Sur>Hap	Seq1	97.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0
	Seq2 TimA	100.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
	Seq2 TimB	100.0	0.0	0.0	0.0	0.0	3.0	9.1	0.0
	Seq3 TimA	100.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0
	Seq3 TimB	100.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0

For almost all of the animations, the intended emotion was the only emotion to be identified above Ekman's (1994) chance rates, for both the first and second emotional expression in the transition. For three animations of 'fear into disgust', surprise was also identified as the first expression above the chance rate of 33% (33.3% for Seq.1, 39.4% for Seq.2 Tim.A, and 33.3% for Seq.3 Tim.A). Similarly, for three animations of 'disgust into surprise', anger was also identified as the first expression above the chance rate of

25% (30.3% for Seq.1, 27.3% for Seq.2 Tim.A, and 33.3% for Seq.3 Tim.B). In just one animation of ‘fear into disgust’, anger was also identified as the last expression above the chance rate of 25% (30.3% for Seq.3 Tim.A).

To assess whether the non-intended emotions were identified significantly above the respective chance rates, the chi-square test was used. For two of the animations of ‘fear into disgust’ (Seq.1 and Seq.3 Tim.A), surprise was identified at the chance rate of 33%. For the remaining animation (Seq.2 Tim.A), identification of surprise as the first expression was not significantly above chance ($\chi^2(1) = 0.546$, $p < .461$, $n = 33$). For the three animations of ‘disgust into surprise’ in which anger was identified as the first expression above 25%, the identification rates were not significantly above chance; Seq.1 ($\chi^2(1) = 0.495$, $p < .483$, $n = 33$), Seq.2 Tim.A ($\chi^2(1) = 0.091$, $p < .764$, $n = 33$) and Seq.3 Tim.B ($\chi^2(1) = 1.222$, $p < .27$, $n = 33$). Finally, for Seq.3 Tim.A of ‘fear into disgust’, identification of anger as the second expression was not significantly above chance ($\chi^2(1) = 0.495$, $p < .483$, $n = 33$). As such - and in contrast with both the previous experiment and artistic predictions - EEC did not have a discernable effect on the identification of non-intended emotions within the animation of expression transitions.

5.3.3.4 Perceived authenticity of animated expression transitions

Participants rated their perceived authenticity of each animation on a 7-point Likert scale of ‘not authentic’ (1) to ‘authentic’ (7). Firstly, the data for all of the animations were compiled into a single data set in order to determine whether EEC had an effect on observer rating of authenticity across all animations. The results of a Friedman ANOVA indicated that the selection of EEC did affect observer rating of authenticity irrespective of the emotion being animated: $\chi^2(4) = 17.643$, $p < .002$, $n = 198$. As with the previous experiment, simultaneous movement (Seq.1) and upper face leading with overlapped timing (Seq.2 Tim.A) choreographies were the most authentic in general, while lower face leading with distinct timing (Seq.3 Tim.B) was the least authentic. Wilcoxon paired comparisons[1] showed that Seq.3 Tim.B was less authentic than Seq.1 ($T = 7628.5$, $r = -0.27$, $n = 198$, $p < .001$), and Seq.2 Tim.A ($T = 7034.5$, $r = -0.26$, $n = 198$, $p < .001$).

The effect of choreography on the perceived authenticity of each of the emotional expression transitions was then assessed. Table 5.11 shows the mean rating for each of the thirty emotional expression transitions. The Friedman test was selected to rank each of the emotional expression choreographies for each emotional expression. The results of the Friedman test for each emotional expression are also shown in Table 5.11. As shown in the table, for four of the emotional expressions, the differences between choreography ratings were found to be significant; ‘happiness into sadness’ ($\chi^2(4) = 10.659$, $p < .032$, $n = 33$), ‘fear into disgust’ ($\chi^2(4) = 9.895$, $p < .043$, $n = 33$), ‘disgust into surprise’ ($\chi^2(4) = 14.593$, $p < .007$, $n = 33$) and ‘surprise into happiness’ ($\chi^2(4) = 17.193$, $p < .003$, $n = 33$). For ‘sadness into anger’ ($\chi^2(4) = 3.350$, $p < .502$, $n = 33$) and ‘anger into fear’ ($\chi^2(4) = 6.341$, $p < .176$, $n = 33$), the differences between EEC ratings were non-significant. Figure 5.13 shows the mean authenticity ratings for each choreographed emotional expression transition. To determine where significant differences lay, the

[1] With a corrected p value of .01.

Table 5.11: The mean authenticity ratings (on a scale of 1-7, where 1 is 'not authentic' and 7 is 'authentic'), Friedman test mean ranks, and Friedman test results for each choreographed emotional expression (EEC) and emotional expression transition.

Transition	Friedman test Critical p value = .05	Mean Rank	EEC ranked least most authentic	Mean Rating
Happiness Into Sadness	$\chi^2(4) = 10.659$, **$p < .032$**, $n = 33$	2.65	Seq2 TimB	5.12
		2.71	Seq3 TimB	5.21
		2.97	Seq3 TimA	5.36
		3.00	Seq1	5.18
		3.67	Seq2 TimA	5.94
Sadness Into Anger	$\chi^2(4) = 3.350$, $p < .502$, $n = 33$	2.70	Seq3 TimB	4.27
		2.85	Seq3 TimA	4.36
		3.05	Seq2 TimA	4.70
		3.11	Seq2 TimB	4.94
		3.30	Seq1	5.03
Anger Into Fear	$\chi^2(4) = 6.341$, $p < .176$, $n = 33$	2.64	Seq3 TimA	4.55
		2.68	Seq3 TimB	4.39
		3.11	Seq2 TimA	4.97
		3.23	Seq1	5.15
		3.35	Seq2 TimB	5.30
Fear Into Disgust	$\chi^2(4) = 9.895$, **$p < .043$**, $n = 33$	2.55	Seq3 TimB	3.73
		2.86	Seq2 TimA	4.27
		2.89	Seq2 TimB	4.33
		3.08	Seq3 TimA	4.64
		3.62	Seq1	5.12
Disgust Into Surprise	$\chi^2(4) = 14.593$, **$p < .007$**, $n = 33$	2.29	Seq3 TimB	3.97
		2.92	Seq3 TimA	4.85
		2.95	Seq2 TimB	4.61
		3.33	Seq1	5.24
		3.50	Seq2 TimA	5.30
Surprise Into Happiness	$\chi^2(4) = 17.193$, **$p < .003$**, $n = 33$	2.32	Seq2 TimB	4.97
		2.68	Seq1	5.42
		3.15	Seq2 TimA	5.79
		3.38	Seq3 TimB	5.91
		3.47	Seq3 TimA	5.91

Wilcoxon signed ranks test was applied to pairs of emotional expression choreographies. A Bonferroni correction was applied to the critical p value, resulting in a value of $p = .01$.

For 'happiness into sadness', the Wilcoxon signed ranks test showed that, of the five choreographed emotional expressions, lower face leading the upper face animation with distinct timing (Seq.3 Tim.B) was significantly less authentic than upper face leading with overlapped timing (Seq.2 Tim.A) ($T = 46.5$, $r = -0.467$, $p < .009$). As such, observers perceived 'happiness into

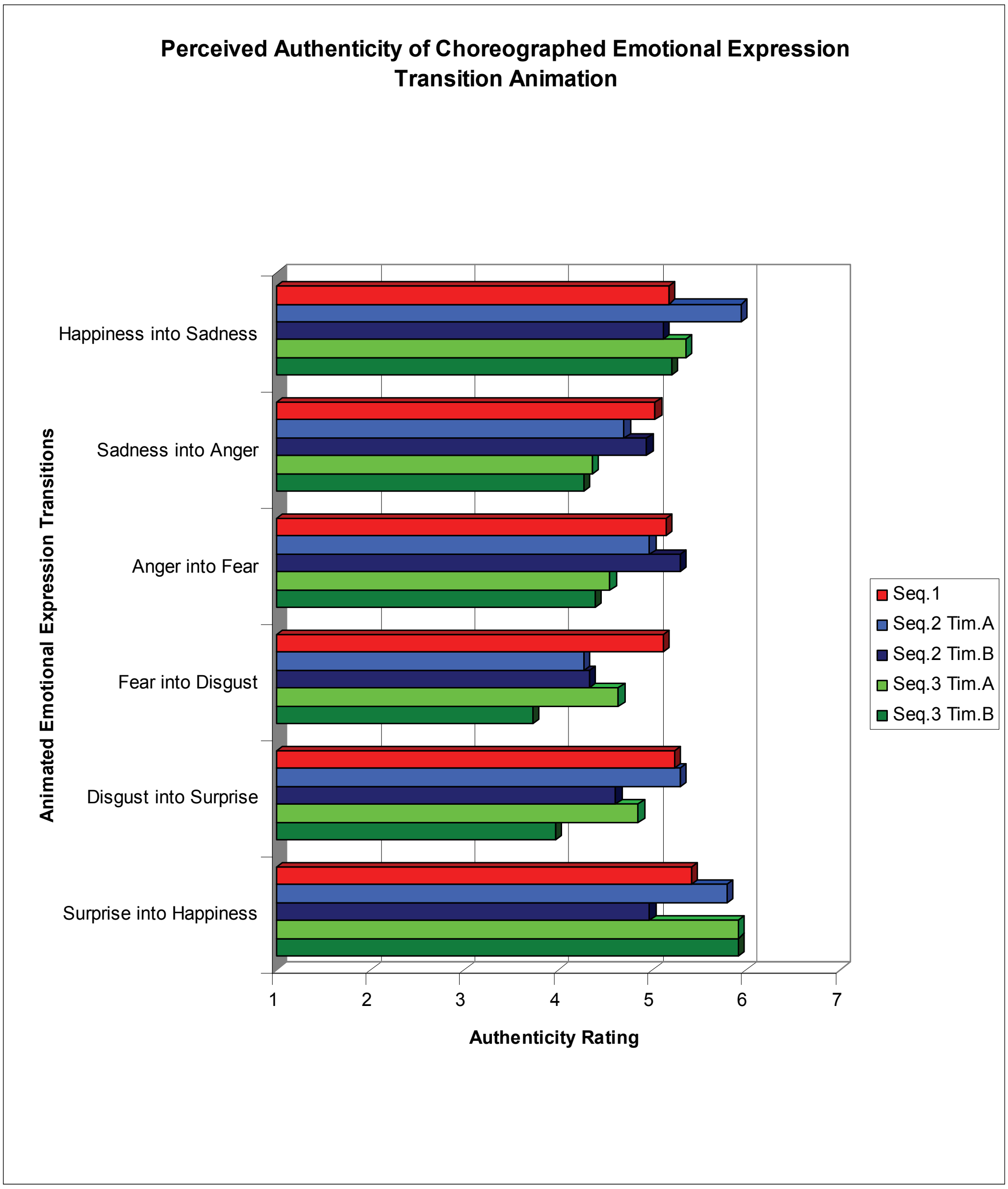


Figure 5.13: Mean authenticity ratings for each choreographed emotional expression transition. A rating of 1 indicates an inauthentic animation and a rating of 7 indicates an authentic animation.

sadness' animations to be more authentic when the upper face led the change in expression, which aligns with the artistic prediction of the practitioner-researcher (see 4.5.3). For animations of 'fear into disgust', lower face leading with distinct timing (Seq.3 Tim.B) was significantly less authentic than both Seq.1 (T = 50.5, r = -0.5, p < .005) and Seq.3 Tim.A (T = 54, r = -0.451, p < .01). In this case, the emergence of simultaneous movement as one of the most authentic transition represented an unexpected result, although lower face leading with overlapped timing (Seq.3 Tim.A) was indeed predicted to be more authentic. For 'disgust into surprise' animations, lower face leading with distinct timing (Seq.3 Tim.B) was significantly less authentic than both simultaneous movement (Seq.1) (T = 75.5, r = -0.446, p < .01) and upper face leading with overlapped timing (Seq.2 Tim.A) (T = 60, r = -0.516, p < .004). This result was consistent with both the artistic predictions as well as the results of the previous experiment (i.e. for 'neutral into surprise', Seq.1 and Seq.2 Tim.A were the most authentic choreographies as well). Finally, for 'surprise into happiness' animations, upper face leading with distinct timing (Seq.2 Tim.B) was less authentic than both timing variations for lower face leading; Seq.3 Tim.A (T = 42, r = -0.483 p < .007) and Seq.3 Tim.B (T = 48.5, r = -0.483, p < .007). This result corroborated the artistic observation that leading with the lower face in animations of 'surprise into happiness' could enhance the believability of the animated transition (see 4.5.2.6).

5.3.4 Discussion

As a follow up to the previous experiment, the current experiment sought to address the research predictions that choreography would have an affect on observer identification and perception of emotional expression transitions, and that the practitioner-researcher's observations would align with experimental findings. The results of the current experiment provided further evidence that manipulation of EEC could affect the authenticity of animated expressions. Additionally, the results broadly corresponded to the artistic predictions which were based on performative methods of creative animation production and reflection (4.4.3). The lack of statistically significant findings relating to the identification of emotions, however, was a somewhat unexpected outcome – especially given the more complex nature of emotional expression transitions.

In terms of the identification of emotion, the results imply that EEC had little to no impact on the identification of either the first or second emotion. While the previous experiment also indicated that choreography had little impact on identification, the results of this experiment suggest no significant effect on observer identification. In all cases, participants accurately identified both the first and second emotion significantly above chance rates, with no confusion with other emotions significantly above chance. In only a handful of cases were non-intended emotions identified at or just above the respective chance rates. These findings indicate that, generally, any choreography could be used to produce easy-to-interpret animation for the emotional expression transitions that were tested. However, the results suggest that certain predicted choreographies could potentially affect identification for better or for worse. For instance, for animations of 'sadness into anger', upper face leading with distinct timing (Seq.2 Tim.B) appeared to enhance observer's ability to identify anger as the second emotion when compared to all four alternative choreographies. In the paired comparisons, the differences between identification rates were non-significant in that the test results did not surpass the critical p value of .01, but the resulting p values were fairly close to this threshold - i.e. the identification rate of Seq.2 Tim.B was bordering significant levels when compared with that of Seq.1 (T = 31.5, r = -0.40, p <

.035, $n = 33$), Seq.2 Tim.A ($T = 35$, $r = -0.29$, $p < .097$, $n = 33$), Seq.3 Tim.A ($T = 24$, $r = -0.33$, $p < .06$, $n = 33$) and Seq.3 Tim.B ($T = 24$, $r = -0.33$, $p < .034$, $n = 33$). It is possible that a larger sample would be needed in order to uncover statistically significant differences in terms of identification, as the differences would appear to be very subtle. The same could be true for the identification of non-intended emotions, for instance the mistaken identification of anger as the first expression in animations of 'disgust into surprise'. On the whole, differences of 10% or more were widespread when EEC identification rates were compared. Although not statistically significant, these differences did corroborate artistic predictions to a degree, and would prove useful information to practising animators.

The results for the observer's perceived authenticity of expression transitions were more conclusive, and in the majority of cases the artistic predictions were accurate. While two expression transitions yielded non-significant results in terms of choreography affecting perceived authenticity – 'sadness into anger' and 'anger into fear' – observer perception of authenticity for the four remaining transitions was clearly shaped by EEC selection. One especially interesting finding was that, for 'surprise into happiness', choreographies that led with the lower face were perceived as being more authentic than choreographies that led with the upper face. In the previous experiment, simultaneous movement and upper face leading choreographies dominated in terms of producing more authentic animation, while lower face leading with distinct timing (Seq3 TimB) in particular was seen as being an inauthentic choreography regardless of emotion. The fact that lower face leading choreographies appeared more authentic for a specific expression transition lends weight to the idea that the overall effectiveness of each EEC cannot be applied generally. In other words, the authenticity of emotional expression choreographies is dependent on the emotional context.

Table 5.12 shows a comparison of the predictions of authenticity made by the practitioner-researcher after reflective practice and the findings of the current experiment. It was observed in the performative study that ‘happiness into sadness’ should lead with the upper face, as the held smile would create a more empathetic mixture of emotion, while the eyes conveyed the change of emotion (see 4.5.3). The results of the current experiment corroborate this observation; participants perceived upper face leading with overlapped timing (Seq2 TimA) to be significantly more authentic than lower face leading with distinct timing (Seq3 TimB) for ‘happiness into sadness’ animation. For ‘fear into disgust’ animation, the results partially backed up the observation that lower face leading with overlapped timing would appear most authentic, in that Seq3 TimA was significantly more authentic than lower face leading with distinct timing (Seq3 TimB). However, simultaneous movement (Seq1) was also significantly more authentic than Seq3 TimB, a finding that was not predicted by the performative study. The results for ‘disgust into surprise’ animation aligned with the artistic observation that surprise should emerge from disgust simultaneously across the face or from the upper face with overlapped timing. Finally, lower face leading with both overlapped and distinct timing (Seq3 TimA and TimB respectively) were both more authentic

Table 5.12: Comparison between the artistic predictions derived from performative research and the findings of the current experiment for each expression transition. Alignment between predictions and findings are highlighted in yellow.

	Performative Predictions		Experimental Findings	
Animation	**Authentic**	**Not Authentic**	**Authentic**	**Not Authentic**
Surprise into Happiness	**Seq.3 Tim.A** or **Seq.3 Tim.B**	**Seq.1** or **Seq.2 Tim.B**	**Seq.3 Tim.A** and **Seq.3 Tim.B**	**Seq.2 Tim.B**
Happiness into Sadness	**Seq.2 Tim.A**	**Seq.3 Tim.B**	**Seq.2 Tim.A**	**Seq.3 Tim.B**
Sadness into Anger	**Seq.2 Tim.A**	**Seq.3 Tim.A** or **Seq.3 Tim.B**	No significant finding	No significant finding
Anger into Fear	**Seq.1** or **Seq.2 Tim.A**	**Seq.2 Tim.B** or **Seq.3 Tim.B**	No significant finding	No significant finding
Fear into Disgust	**Seq.2 Tim.A** or **Seq.3 Tim.A**	**Seq.2 Tim.B** or **Seq.3 Tim.B**	**Seq.1** and **Seq.3 Tim.A**	**Seq.3 Tim.B**
Disgust into Surprise	**Seq.1** or **Seq.2 Tim.A**	**Seq.2 Tim.B** or **Seq.3 Tim.B**	**Seq.1** and **Seq.2 Tim.A**	**Seq.3 Tim.B**

than upper face leading with distinct timing (Seq2 TimB), backing up the observation that the most believable transitions from surprise to happiness would begin with the mouth.

To return to the research questions, then, the results of the current experiment indicate that the effect of choreography on identification of emotions is fairly limited, and that to observe any real effect may require a much larger sample. This finding is somewhat similar to the findings of experiment 1, although some significant results were produced with a similar sample size previously. More evident was the effect of choreography on perceived authenticity – the use of EEC had a clear impact on how observers interpreted the transitions, with different choreographies being more or less effective dependent on the emotional expression transition. Furthermore, the observations that emerged from the performative phase were again shown to be accurate indicators in terms of predicting observer perception of animated expressions.

5.4 Chapter summary

The results discussed in this chapter – particularly in regards to experiments 1 and 2 – demonstrate that EEC can significantly affect observer perception of animated faces. While the initial choreography proposition[1] proved difficult to test experimentally, the simplified adaptation of the concept[2] allowed for a more fruitful investigation of the effects on audiences of emotional expression choreography. Furthermore, it was shown that the emotional context of the animations – for instance, the expression of a single emotion (such as happiness) or a change in expression (such as 'anger into fear') – determined the effectiveness of each level of EEC. In other words, of the five choreographies that were ultimately tested, none were universally effective – EECs were perceived as more or less authentic depending on the emotion(s) being animated. For example, simultaneous movement (Seq.1) and upper face leading with overlapped timing (Seq.2 Tim.A) were seen as more authentic than alternative choreographies for animations of surprise. On the other hand, for animations of 'surprise into happiness', lower face leading with overlapped (Seq.3 Tim.A) or distinct (Seq.3 Tim.B) timing were perceived

[1] The proposition that the sequence, timing, severity, and duration of three facial regions (brows, eyes, and lower face) could be manipulated in order to affect observer perception, in terms of observer identification of emotion and perceived authenticity (see section 4.1.3).

[2] Reducing the number of facial regions from three to two, then focussing on sequence and timing (see section 4.3.1). This effectively decreased the number of experimental levels to a more feasible 5.

as the most authentic choreographies. This was an important finding, as it underlined that emotional context ought to be taken into account when determining the sequence and timing of facial regions, and that, in general, one facial region cannot be said to be of greater temporal importance than the other[1].

In both of the major studies presented in this chapter, it was found that EEC did not significantly affect observer identification of the intended emotion. In only one case did EEC significantly affect identification of alternative emotions (the animation of the disgust expression). This outcome could be in part due to the cyclic artistic process of animation production, in that the goal of the practitioner-researcher was to find ways to make each EEC work in practice. As a consequence of artistic endeavour using choreography as a framework, most of the animations were clearly identifiable as the intended emotion, and the experimental findings could not be used to determine which EEC made for the clearest animation of each expression or transition. In this scenario, the observations of the practitioner-research are perhaps more informative than the experimental results, as they shed light on how more complex interpretations (such as emotional or narrative context) could be manipulated by choreography, and take into consideration both the principles of animation and the related literature on emotional psychology. In other words, it may be difficult if not impossible to detect measurable differences in perception brought about by the application of EEC using an experimental method. While effects were found for

[1] This links back to Chapter 2, in which a number of broad statements from animation literature were discussed. While Kalwick (2006) was not specifically discussing sequence or timing, his statement that "the mouth is the foundation of every expression" (p 74) is here shown to be contextually dependent and not universal.

authenticity, adding scientific weight to the proposition that EEC can manipulate a general audience's perception of emotion, it is clear that other methods are essential in order to fully understand the role of EEC. Corroboration between performative and quantitative findings demonstrated that viewing EEC from multiple perspectives could generate more detailed insights into its potential. This conclusion justified the selection of a mixed-methods approach, including the arts-based investigation, scientific experimentation, and qualitative research – the subject of the next chapter.

Chapter 6

Qualitative studies of facial animation: investigating the intersubjective experiences of animation production and perception

> "For decades social scientists have sought to improve the quality of their research by perfecting scientific procedures. Social scientists adopted experimental design strategies used in physical and biological sciences. Randomization, control groups and experimental designs became popular. However, scientists were soon disappointed, for while they learned a great deal they found that this positivistic approach actually limited their thinking and overlooked valuable data"
> (Krueger and Casey, 2009, p 199)

It has been demonstrated that manipulation of the sequence and timing of facial regions during expressions of emotion can have small but significant effects on the way observers perceive facial expressions. These findings were the result of a highly experimental approach to expression perception research, which was dependent upon a positivist ontological perspective and careful measurement of observer responses. However, facial expressions of emotion – particularly dynamic expressions – are enormously complex. Even when the appearance of facial regions is generalized and based on images of accepted 'universal' expressions, it may not be possible to discriminate between very similar expressions of emotion using a simple measurement such as 'perceived authenticity'. For instance, whilst it is now known that a dynamic expression of sadness can look more authentic when the eyes lead the movement, the reasons why certain choreographies appear authentic remain unclear.

The performative research discussed in Chapter 4 provided a highly subjective insight (based on iterative and reflective practice) into why particular choreographies may or may not work, but ultimately this research was limited by its focus on artistic method and the interpretation of a single practitioner. Conversely, the experimental approach discussed in the previous chapter highlighted the significant effects variation in sequence and timing could have on a general audience, but this approach could only be used to identify (and not explain) differences in choreography perception. In order to shed light on *why* EEC might affect observer interpretation, a qualitative approach to research was needed – an approach which would focus on the experiential encounters other animators and observers have with emotional expression choreography.

As discussed in Chapter 3, phenomenological research methods can be applied to the study of emotional facial expressions. Within this qualitative research framework, the emotional expressions must be treated as phenomena experienced by animators and observers. From the phenomenological perspective, a relatively small number of cases are typically explored, with the aim being to "reveal something of the experience of each of those individuals" (Smith, Flowers and Larkin, 2009, p 3). It was therefore put forward that, by undertaking phenomenological research into emotional expression animation production, it would be possible to explore animator's intersubjective interpretation of choreography, and thus unravel a more detailed understanding of the EEC concept. Additionally, it was proposed in Chapter 3 that animation perception could be researched from a qualitative angle, allowing for a more detailed study of audience interpretation that would go beyond the measurement of specific perceptual attributes.

This chapter therefore covers two qualitative studies; one of animation production, and one of animation perception. The first study, relating to the intersubjective interpretation of a group of student animation practitioners, is discussed in sections 6.2 and 6.3. The second study, relating to the intersubjective interpretation of animation audiences, is discussed in sections 6.4 and 6.5. Throughout this chapter, reference will be made to the research materials used in the qualitative analysis of animation production and perception. The data for these studies is included as appendices and on the accompanying DVD. Firstly, section 6.1 covers an initial phase of the phenomenological study – an analysis of the researcher's own experience of producing and observing choreographed emotional expressions.

6.1 The researcher's experience of emotional expression choreography

Prior to collecting data from participants on their interpretation of animation development, the first stage of the phenomenological study was to describe the practitioner-researcher's experience of animating emotional facial expressions. The decision to follow a method of qualitative analysis for the researcher's own experience was seen as an important step towards achieving reliability and quality in the subsequent research (Moustakas, 1994). This phase of research stemmed directly from the performative research discussed in Chapter 4, which made use of journaling for recording personal observations, and structured reflection for organizing those observations into informed artistic predictions. These predictions related to the expected usability of each of the five levels of EEC (i.e. the sequence and timing of upper and lower facial movements during expressional changes). The aim was to extend the results of the performative study by identifying a range of potential themes related to emotional expression choreography. The process for developing the themes and descriptions was Moustaka's (1994) modification of the Stevick-Colaizzi-Keen method[1]. Ultimately, the emergent themes and the researcher's descriptions would inform the analysis of participant data, and support a comparison between the researcher's and the participant's experiences. To achieve this, a full description of the practitioner-researcher's personal experience was required. Due to the design of the performative research methods, this already existed in the form of structured reflection documents detailing observations and reflections during and following practice.

6.1.1 Invariant horizons

The researcher broke down his structured reflections into statements. Table 6.1 shows an excerpt from the horizonalization of the practitioner-researcher's structured reflection. In this case, the reflection on animating happiness using Seq.1 was analysed. By analysing these statements it was possible to determine a range of meaning units which related to the experience of the practitioner-researcher while producing and evaluating

[1] This process of phenomenological data analysis is described in full with detailed examples in Moustakas (1994) pp.120-154.

animation. The next stage of the Stevick-Colaizzi-Keen method concerned the grouping of these meaning units into core themes.

Table 6.1: Excerpt from the horizonalization of the researcher's structured reflection. In this example, the researcher's reflection on the animation of 'neutral into happiness' is broken down into significant statements, with horizons (meaning units) assigned to each statement in the right hand column.

Statement	Meaning Units
1. With this choreography I was trying to achieve a believable reaction of happiness, as this seemed the most appropriate use for simultaneous movement.	Believable/authentic Emotional reaction
2. It is very difficult to move the upper face to the desired shape when the mouth does not lead action.	Practical difficulty
3. The raised cheeks and squint that is apparent in happy expressions are results of upward movement from the lower face.	Anatomical movement Typical appearance
4. By forcing simultaneous action, more time needs to be spent refining and altering the strength and speed of shapes to avoid unbelievable results.	Strength of movement Speed of movement
5. As a pure reaction, I think that this could work well – but that it may need additional rigid head motion to create a more believable expression of happiness.	Emotional reaction Pure emotion Believable/authentic
6. In some ways this choreography does appear quite logical, when a specific context is used (e.g. reactionary happiness).	Artistic logic/intuition Within a particular context Emotional reaction
7. Stylistically, it could be logical in a caricatured cartoony way – the sudden appearance of happiness all over the face should make the emotion unmistakably clear	Character type (cartoon) Emotional clarity
8. However, in an anatomical sense it cannot be seen as a highly logical choreography, as the lower face plays some part in upper face shape development.	Anatomical movement Typical movement

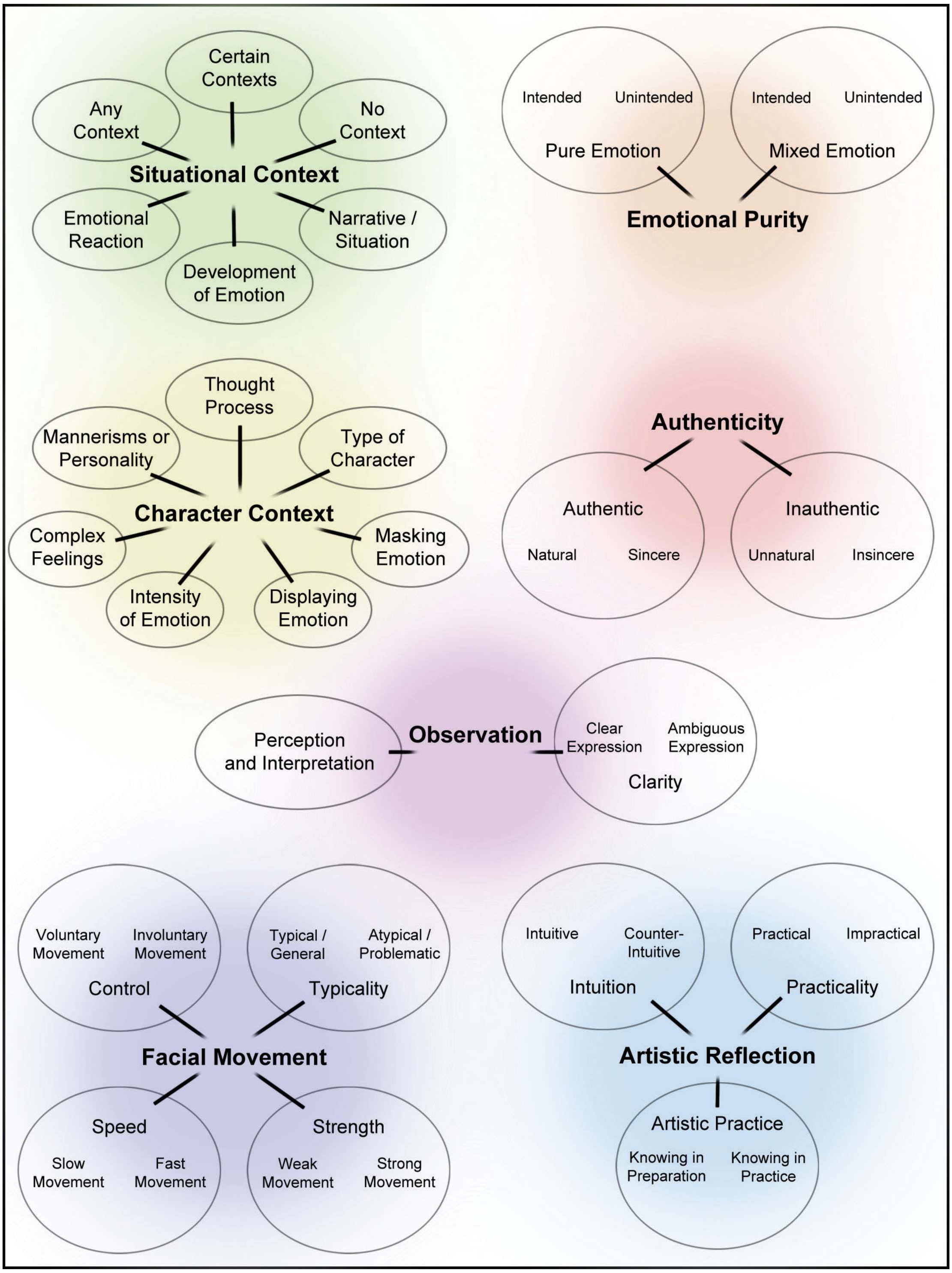


Figure 6.1: The meaning units identified and clustered into seven major themes.

6.1.2 Themes

From the initial horizonalization process, twenty-six meaning units were identified. Figure 6.1 shows how these meaning units were then clustered under seven major themes; authenticity, observation, emotional purity, character context, situational context, facial movement, and artistic reflection. Appendix XXV covers the descriptions of each meaning unit and how these meaning units were inputted into *NVivo 8* in order to systematically analyse participant data.

6.1.3 A Description of the practitioner-researcher's experience with animation production

Using the meaning units and themes listed and identified in the previous phase of analysis, the structured reflection documents were coded in full in order to filter statements by theme. The next stage of the Stevick-Colaizzi-Keen method involved synthesizing themes into descriptions of the practitioner-researcher's experience. As discussed in Moustakas (1994), these descriptions are used to communicate the nature of the individual's encounter with the phenomenon, and to explore how major themes emerge through analysis of statements. This aspect of the phenomenological method was essential in order to clearly declare the researcher's own position on the concept of EEC. A structural description of the practitioner-researcher's experience is included in Appendix XX.

6.2 A phenomenological study of animation production

With a full account of the practitioner-researcher's experience completed, the qualitative study of animation production could commence. The purpose of this study was to engage a cohort of student animators with the concept of emotional expression choreography, task them with producing their own animations, and determine whether the subjective interpretations of the practitioner-researcher (Chapter 4) could be reconciled with the interpretations of fellow animators.

6.2.1 Research questions

In order to guide the phenomenological study of animation production, the following research questions were posed:

I. Do student animators show majority consensus when discussing the authenticity and clarity of emotional expression choreographies, as applied to each expression and transition?
II. Do student animators reveal deeper interpretations of the effects of emotional expression choreography, such as expression context or the nature of the character?
III. To what extent do the findings support the practitioner-researcher's stance on emotional expression choreography as applied to a range of expressions?

Due to the nature of exploratory qualitative research, no exact predictions were made regarding the outcome of this study. Nevertheless, it was expected that the participants would demonstrate a high level of reflective-practice during and after the generation of animation, and that, as a result, artistic interpretations of the role of EEC would be revealed. It was predicted that participants would offer detailed insights, developed through studio practice, which would demonstrate their interpretation of; the application of EEC, the effect of EEC on animation authenticity and clarity, and the wider context of EEC in animation. Additionally, it was predicted that the findings would allow for a comparison with the findings of the performative research, which was conducted by the practitioner-researcher in isolation. As such, this study was designed in order to build upon and substantiate the artistic findings discussed in Chapter 4. Where the performative study involved a single practitioner-researcher, the current study involved a group of student animators tasked with animating expressions within the EEC framework. Coupled with the performative study, it was predicted that the current study would demonstrate that studio practice could act as a catalyst for new knowledge regarding the movement of expressions, distinct from quantitative experimental studies discussed in Chapter 3 and presented in Chapter 5.

6.2.2 Method

As a phenomenological study, the most appropriate methods of data collection were identified as interviews and diaries (see Smith, Flowers and

Larkin, 2009, pp.56-78). For the purposes of this study – a study of participant encounters with facial animation practice over several weeks – diaries emerged as an appropriate primary data collection method. As such, participants were asked to maintain and update diary documents as they completed the various stages of the animation project (this is covered in 6.2.2.2). Once participants had completed their animation projects, and thus encountered EEC in animation production, interviews were used to collect more in-depth accounts of participant experiences.

6.2.2.1 Sample and site of research

In accordance with phenomenological methodology (Colaizzi, 1978; Moustakas, 1994), participants were selected based on their experience with the phenomenon under investigation. In this study, the phenomenon was the experience of animating emotional facial expressions, in particular animating the expressions using the final framework of EEC (see 4.3.1). As the choreography framework was unique at the time of the study, an existing sample was not available at the start of the research. To rectify this, steps were taken to manufacture a situation whereby potential participants could experience the phenomenon under fairly natural conditions.

Two classes of computer arts and animation students studying at the University of Abertay Dundee were identified as participants. These were one third year undergraduate class of approximately 29, and one postgraduate class of approximately 16. In order to expose these students to the concept of choreographing emotional facial expressions, the researcher developed and delivered a series of lectures and tutorials which covered; the anatomy of the human head and face, the muscles and muscle groups activated during expressions including an overview of FACS (Ekman and Friesen, 1978), the appearance of the universal expressions from artistic and scientific perspectives, the animation of facial expressions, and the final framework of EEC (discussed in Chapter 4). In addition to the delivery of lectures and tutorials, the researcher also assigned animation exercises that would encourage the students to experiment with choreography and produce a range of animated expressions. For these exercises, the students were provided with the facial animation rig used by the researcher (described in Appendix IX).

The group of approximately 45 students who attended the lectures and tutorials were invited to participate in an extended study of facial animation. From this group, 7 went on to complete the project (4 female, 3 male), Participants were aged between 21 and 30, 5 were enrolled in the third year of the undergraduate programme and 2 in the postgraduate programme. One of the postgraduate students had previously studied for an undergraduate degree in animation. All seven participants had some experience working with specialist animation software (*Maya 2008*) prior to the start of the project, all had some artistic training and experience, and all had received official animation training as part of their studies.

The participants worked on the project (see 6.2.2.2) for 8-10 weeks. They worked individually in their spare time, using either the PCs on the university campus or their own PCs at home. The final interviews with participants took place in March and April 2010. At the start of the study participants were informed that they would receive £20 for participating, and this was paid to participants after the interview. Throughout this thesis and in all appendices, participants have been assigned pseudonyms in order to protect their anonymity.

6.2.2.2 Animation tasks and procedures for data collection

Participants were asked to create a range of facial animations using the Emotional Avatars facial rig (Appendix IX). Firstly, participants were given a thorough briefing of the project, prior to signing an informed consent document (see Appendix XXI). At this stage, participants were made aware of the nature of the project, were given a rundown of the creative and technical work involved, and were informed that their data would be used in analysis and potentially in publication. All seven participants were asked to produce twelve facial animations, split into two sets of six. The first six animations were the universal expressions of emotion (happiness, sadness, anger, fear, disgust, and surprise), starting from a neutral face. The second set of animations were emotional expression transitions (surprise into happiness, happiness into sadness, sadness into anger, anger into fear, fear into disgust, and disgust into surprise). For each of the twelve animations, the participants were asked to experiment with EEC, specifically using the framework of five choreography levels established in 4.3.1 (simultaneous movement, upper face leading with overlapped timing, upper face leading with distinct timing, lower face leading with overlapped timing, and lower face leading with distinct timing). As such, these two sets of animation aligned with the previous artistic studies of facial animation carried out by the practitioner-researcher (see 4.4 and 4.5) and the subsequent tests of observer perception (see 5.2 and 5.3). In order to record data during the animation production process, participants were requested to complete pre-animation questionnaires and post-animation evaluations prior to submitting their work. The templates for these documents are included as Appendix XXI, while the completed documents for all participants are included as Appendix XXII. The structure of the animation project – consisting of six exercises – is shown in Table 6.2.

6.2.2.3 Interviews with participants

After completing the six exercises described in the previous section, participants were invited to one-on-one interviews which were conducted by the researcher. The purpose of the interviews was to collect in depth information regarding participant's experience in general. The interview schedule is included as Appendix XXIII, while full interview transcripts for each participant are included as Appendix XXIV.

6.2.2.4 Analytical procedure and data reliability

In order to collect and analyze qualitative data generated by the participants, the procedure of interpretative phenomenological analysis (IPA) discussed by Smith, Flowers and Larkin (2009, pp.79-107) was used as a framework. This form of thematic analysis was deemed most appropriate as the research was predominantly concerned with revealing the deeper, subjective perceptions of the involved participants after experiencing

Table 6.2: The six exercises completed by the participants who were engaged with the project.

Animation Project Exercises		
Exercise	**Title**	**Description**
1	Preparation for animation of expressions	Pre-animation experimenting with the six universal expressions, using only a mirror, video camera, observation of others, and sketching to aid decision making. Findings recorded in the Preparation for Animation (part 1) document.
2	Production of expression Animation	Animation of the six universal expressions using Maya 2008 software and the Emotional Avatars facial rig.
3	Evaluation of expression animation	Reflection on the animation process and final outcomes. Findings and observations recorded in the Evaluation of Animation (part 1) document.
4	Preparation for animation of transitions	Pre-animation experimenting with the six expression transitions, using only a mirror, video camera, observation of others, and sketching to aid decision making. Findings recorded in the Preparation for Animation (part 2) document.
5	Production of transition animation	Animation of the six expression transitions using Maya 2008 software and the Emotional Avatars facial rig.
6	Evaluation of transition animation	Reflection on the animation process and final outcomes. Findings and observations recorded in the Evaluation of Animation (part 2) document.

animation production. Data reliability was achieved through a combination of; laying bare the researcher's presuppositions about the phenomenon (Colaizzi, 1978) by conducting the initial analysis (6.1), forwarding commented transcripts to participants to be checked and confirmed as being accurate interpretations (Moustakas, 1994, p 110), and making all research materials available in the appendices for independent audit (Smith, Flowers and Larkin, 2009, p 183).

6.3 Analysis of animation production data

Following the IPA method, diary documents and interview transcripts were firstly read in their entirety, before the documents were broken down into experiential statements. Descriptive, linguistic, and conceptual comments were noted alongside participant transcripts (see Appendix XXIV). These notes were then sent to participants for checking. Line by line analysis of participant transcripts revealed that many of the major themes identified in section 6.1 could also be attributed to participant experiences. In particular, participants provided detailed interpretations of EEC and how it could affect; the authenticity of animation, the clarity of expressions, and the context of the expression (in terms of both the character and the possible situation). Additionally, participants discussed how they felt about animating expressions in the studio, including how intuitive certain EECs were and how their opinions were either strengthened or changed through practice. The themes initially established in section 6.1 were expanded based on analysis of participant transcripts. The final breakdown of themes and meaning units is provided in Appendix XXV. The following sections detail participant discussion of authenticity, clarity, context and character, and artistic reflection after coding the seven interview transcripts. These results are due to be published in Sloan et al. (2011).

6.3.1 Themes

6.3.1.1 Authenticity

Participants were clearly able to extract an artistic interpretation of how authentic EECs were. Interpretations of authenticity were evidenced in the preparation and evaluation documents as well as interview transcripts, with all seven participants making substantial reference to how authentic or inauthentic they believed an EEC was after experimenting with its application in practice. In particular from the interview transcripts, it emerged that participants showed some consensus regarding the authenticity of the five choreographies in general. Six of the seven participants stated a preference for upper face leading with overlapped timing (Seq.2 Tim.A) when considering authenticity, while four participants indicated that lower face leading with distinct timing (Seq.3 Tim.B) was especially inauthentic:

> "…the overlap definitely, the other one not so much, but the overlap definitely worked for a genuine smile or fear."
> (Tricia interview, Appendix XXIV)

> "I think quite natural is starting from upper face, and affecting the lower face. I think maybe this one includes all of them it, it looks more… thought provoking in most cases, because… it looks like you are thinking."
> (Wendy interview, Appendix XXIV)

> "I felt that if the lower face peaked before the upper face, if the eyes didn't squint when the lower face peaked I felt that was quite fake. It didn't feel fluid, the eyes remained stationary"
> (Steven interview, Appendix XXIV)

> "I found that usually they were the ones that were completely unusable just because it seemed so unnatural for one half of the face to move without the other."
> (Rory interview, Appendix XXIV)

Beyond stating that animations appeared authentic or inauthentic, it was clear from the analysis that the participants considered the precise nature of the animations when reflecting on their work. From the interview transcripts, participants discussed how natural (4/7), unnatural (5/7), sincere (3/7) and insincere (4/7) choreographies appeared:

> "If you were trying to show someone that was trying to be fake or was trying to be nervous, then different choreographies would work."
> (Helen interview, Appendix XXIV)
>
> "If you were faking an emotion or someone has maybe told you just to look happy you'd maybe use choreography 1 because you are trying to look happy quickly for them…"
> (Rory interview, Appendix XXIV)
>
> "I think that the delay of going up or down, when you are watching that on screen, if its slowed down it can look fake, if it's fast it can look like an overlap anyway, so those ones felt more natural to me."
> (Tricia interview, Appendix XXIV)

Through reflective-practice, the student animators therefore demonstrated an awareness of the authenticity of their animation, and the potential impact of variation in sequence and timing. That the participants shared the view of the practitioner-researcher regarding the general authenticity of Seq.2 Tim.A and often inauthentic appearance of Seq.3 Tim.B was an important finding, indicating that a degree of intersubjective consensus had been reached between animation practitioners on the general effect of EEC on expression authenticity.

6.3.1.2 Clarity

Additionally, analysis of interview transcripts demonstrated that participants were interested in determining how EEC could affect expression clarity (6/7 participants). Although there was no evidence that particular EECs would greatly enhance or degrade clarity in general, participants discussed how choice of EEC could impact on their interpretation of how clear or ambiguous an animation would be:

> "You wouldn't be quite sure, some of them were looking more confused than disgusted, and it was like the lines were quite blurred, but then you'd do a different choreography, and all of a sudden the emotion would be quite clear, that it was disgust…"
> (Helen interview, Appendix XXIV)
>
> "Some of them were very clear as to what emotion they would work for, others I think had barriers, you could use a couple depending on the scenario of it."
> (Tricia interview, Appendix XXIV)
>
> "If you used one of the choreographies, I think it was the mouth first, it didn't look like disgust it looked more like surprise or something first. There were points where you definitely couldn't use, like, certain choreographies because it made it look like it was going into a completely different one."
> (Luke interview, Appendix XXIV)

As such, participant data demonstrated that engagement with producing choreographed animations could lead to a subjective interpretation of expression clarity. The question of whether there was a degree of intersubjective consensus on the effect of choreography on specific emotions is addressed on a case by case basis in sections 6.3.2 and 6.3.3.

6.3.1.3 Context and character

Analysis of the transcripts showed that all participants considered how choreography could be connected to the potential context (7/7) or character (6/7) of the animation. On context, participants broadly indicated that particular choreographies may be applicable to certain scenarios (5/7) or a development of emotion (4/7).

> "So even though all my animations are simple, there is no context or story, but if context is applied to each scenario, then some of these other choreographies may be more useful. So all of them are right I think, it just depends on the context."
> (Tricia interview, Appendix XXIV)

> "…looking at how expressions are actually animated using different choreographies and stuff sort of shows how they'd be better off used in certain choreographies and certain situations. So you don't always use the same expression. It's the same expression but it's shown in a slightly different way depending on what you are doing."
> (Rory interview, Appendix XXIV)

> "It definitely worked quite well, for… I think it was… anger I think it was, because you sort of have the eyebrows slowly move first downwards way and it shows that you are slowly getting angry."
> (Luke interview, Appendix XXIV)

As regards character, participant comments in the interviews showed that engagement with choreography in animation production led to reflective insights on the nature of the character being animated. This included the potential thought process of the character (5/7), complex emotional states or feelings (4/7), and deliberate displays of emotion (5/7). Evaluation of these comments was of particular interest, as it demonstrated that animation and reflection could offer clues as to the effect of EEC on aspects of the expressions which could not be explicitly measured (see Chapter 5).

> "…choreography 2 worked really well, because it really showed visually what was going on in the mind of the subject."
> (Steven interview, Appendix XXIV)
>
> "I think quite natural is starting from upper face, and affecting the lower face. I think maybe this one includes all of them it, it looks more… thought provoking in most cases, because… it looks like you are thinking."
> (Wendy interview, Appendix XXIV)
>
> "…if they are trying to act like… they are nervous and you are trying to show more of a nervous smile, then obviously you wouldn't pick the genuine happiness choreography."
> (Helen interview, Appendix XXIV)

6.3.1.4 Artistic reflection

Lastly, coding of the meaning units under the major theme artistic reflection demonstrated that participants experienced intuition (4/7) when attempting to animate using EEC. Here, participants discussed whether they liked or did not like an EEC, and whether they felt it was natural or instinctive in practice.

> "Just because for most of the expressions they felt really natural and quite instinctive."
> (Rory interview, Appendix XXIV)
>
> "…the overlapping was the one that stood out for me so I always wanted to go for that because for me artistically that's what looked correct."
> (Tricia interview, Appendix XXIV)
>
> "I felt that if the lower face peaked before the upper face, if the eyes didn't squint when the lower face peaked I felt that was quite fake. It didn't feel fluid, the eyes remained stationary."
> (Steven interview, Appendix XXIV)

Additionally, participants commented on the practicality (5/7) of choreographies, in terms of how difficult they were to implement in practice and whether the outcome would be useful in an animation.

> “But they did give me a headache, some of them. Some of the choreographies were really difficult to do.”
> (Helen interview, Appendix XXIV)
>
> “…it was a lot easier to have one peak then have the other one go after that. Because you are not trying to move all these different muscles, whereas with choreography 3 you moved one set then the other.”
> (Luke interview, Appendix XXIV)

Overall, then, it was evident from the interview transcripts that participants encountered issues with authenticity, clarity, context, character, and artistic reflection when producing animations of emotional expressions. Other themes identified in section 6.1 were also coded when analysing transcripts. Full, commented interview transcripts are included as Appendix XXIV. These findings went some way towards answering the third research question, demonstrating that the cohort of student practitioners – over a much shorter period of time – considered the same choreography effects initially identified by the practitioner-researcher after structured reflection. In the next two sections of the chapter, analysis of the participant evaluation documents for each of the twelve expression animations is discussed.

6.3.2 Choreographing emotional expression animation

From the evaluation documents, it was possible to discern a detailed account of participant encounters with each of the six emotional expression animations, using the full range of EECs. At the end of the evaluation exercise, participants were requested to state which choreographies they believed were the strongest and the weakest, summarising their views on each. Figure 6.2 shows the spread of participant opinions on the success or failure of each of specific choreographies as applied to the six emotional expressions. Instances where there was agreement between more than 33% (3/7) or more than 50% (4/7) of the participants are highlighted. Choreography Seq.3 Tim.B (lower face leading with distinct timing) was clearly deemed the weakest EEC in general, with high levels of agreement between participants for sadness, anger, fear, and surprise. The strongest choreographies were simultaneous movement (Seq.1) – which was deemed effective for disgust, surprise, and to a lesser extent for anger – and upper face leading with overlapped timing (Seq.2 Tim.A) which was preferred when animating sadness and fear. Complete agreement between all participants was not reached in any case, and a spread of subjective opinions was apparent in determining the strongest EECs for happiness and anger, and the weakest EEC for disgust. In the following sections, each of the animated emotions shall be examined with reference to participant comments derived from the evaluation documents. Completed evaluation documents for this study are included as Appendix XXII, while examples of the coded comments which substantiate the findings for each emotion are listed in Appendix XXVI.

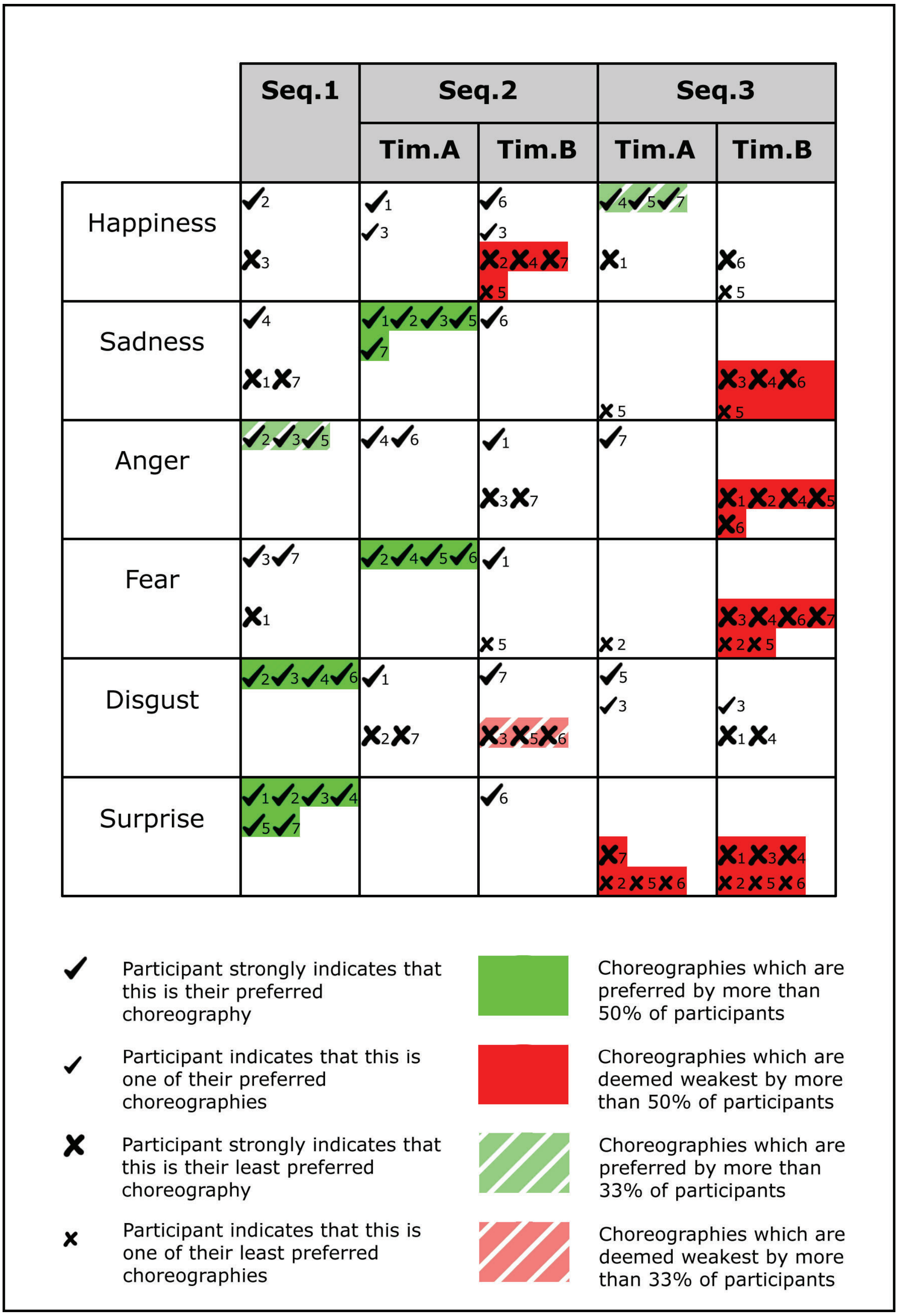


Figure 6.2: Final judgements by all participants regarding their most and least preferred choreographies when animating the six universal emotional expressions.

6.3.2.1 Neutral into happiness

Although the participant preferences for happiness were spread, the authenticity of Seq.3 Tim.A, Seq.2 Tim.B and Seq.3 Tim.B was discussed by more than 50% of the participants. Leading with the lower face with overlapped timing (Seq.3 Tim.A) was seen as being quite authentic, with participants describing it as being genuine, natural, and believable, while the other two EECs were broadly seen as being inauthentic or faked. The effects on clarity were not discussed by many participants, but 4/7 participants discussed context or character when evaluating Seq.1 and Seq.2 Tim.B. Simultaneous movement (Seq.1) was seen as being useful in certain contexts, in particular where the character was required to intentionally feign a smile (a social smile) or to laugh. Less agreement was apparent for the context of Seq.2 Tim.B, although the presence of a thought process was observed. Table 6.3 shows the coding frequency for participant discussion of authenticity, clarity, context, character, and artistic reflection.

Table 6.3: Themes coded for animations of happiness after analysis of participant evaluation documents.

Choreographing 'Neutral into Happiness'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	1/7	3/7	2/7	4/7	0/7
Creates inauthentic expression animation	3/7	3/7	4/7	3/7	4/7
Creates a clear expression of emotion	1/7	0/7	0/7	0/7	1/7
Creates an ambiguous expression of emotion	1/7	0/7	2/7	0/7	1/7
Discussed context	4/7	0/7	4/7	3/7	2/7
Discussed character	4/7	1/7	4/7	2/7	3/7
Considered an intuitive choreography	4/7	3/7	2/7	4/7	1/7
Considered a counterintuitive choreography	1/7	1/7	0/7	0/7	1/7
Considered a practical choreography	3/7	0/7	0/7	0/7	1/7
Considered an impractical choreography	1/7	3/7	1/7	1/7	3/7

6.3.2.2 Neutral into sadness

For sadness, it was evident that the participants strongly favoured leading from the upper face with overlapped timing (Seq.2 Tim.A). Comments indicated that this EEC created an authentic and clear result – for example, it was regarded as the “most believable and easiest to read” (Steven), as a “genuine sadness” (Helen) and it was stated that it “looks and feels natural and believable” (Rory) (see Appendix XXVI). There was strong emphasis on the tacit understanding of how easy it was to animate sadness using Seq.2 Tim.A – e.g. that it “feels the most natural way to animate” (Tricia). Conversely, lower-face leading choreographies were seen as inauthentic. In particular, Seq.3 Tim.B was regarded as unnatural and insincere, with a range of comments indicating that it would only be useful in a context where sadness was “being forced” (Helen) or falsely displayed. Context was also discussed for Seq.2 Tim.B, which was identified as a potentially successful choreography but one which contained a higher degree of cognitive appraisal (or thought process).

Table 6.4: Themes coded for animations of sadness after analysis of participant evaluation documents.

Choreographing ‘Neutral into Sadness’					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	1/7	6/7	3/7	0/7	0/7
Creates inauthentic expression animation	3/7	0/7	2/7	4/7	5/7
Creates a clear expression of emotion	0/7	4/7	2/7	0/7	0/7
Creates an ambiguous expression of emotion	0/7	0/7	1/7	1/7	3/7
Discussed context	3/7	0/7	5/7	3/7	4/7
Discussed character	3/7	1/7	4/7	3/7	6/7
Considered an intuitive choreography	0/7	6/7	1/7	0/7	0/7
Considered a counterintuitive choreography	2/7	0/7	0/7	2/7	2/7
Considered a practical choreography	2/7	2/7	1/7	1/7	1/7
Considered an impractical choreography	2/7	0/7	0/7	1/7	1/7

Table 6.5: Themes coded for animations of anger after analysis of participant evaluation documents.

Choreographing 'Neutral into Anger'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	3/7	5/7	3/7	2/7	1/7
Creates inauthentic expression animation	1/7	0/7	2/7	3/7	5/7
Creates a clear expression of emotion	3/7	5/7	1/7	0/7	0/7
Creates an ambiguous expression of emotion	0/7	0/7	0/7	3/7	4/7
Discussed context	2/7	3/7	5/7	2/7	0/7
Discussed character	2/7	0/7	4/7	2/7	2/7
Considered an intuitive choreography	3/7	4/7	1/7	0/7	0/7
Considered a counterintuitive choreography	0/7	0/7	1/7	0/7	1/7
Considered a practical choreography	3/7	3/7	1/7	1/7	0/7
Considered an impractical choreography	0/7	1/7	1/7	0/7	3/7

6.3.2.3 Neutral into anger

As with sadness, the majority leaned towards Seq.2 Tim.A as an effective choreography for anger, and Seq.3 Tim.B as an ineffective choreography. The former was underlined as reliable, particularly so in that the resulting animation of anger was widely regarded as being unambiguous. In one example it was indicated that Anticipation may be at play – "you can tell straight away the emotion about to be delivered" (Rory). The impact of the eyes and brows on the clarity of the expression made Seq.2 Tim.A the most intuitive EEC for anger, and the participants stated that the outcome was believable. On the other hand, Seq.3 Tim.B was determined to be both inauthentic and ambiguous, with participants suggesting once more that this particular EEC made for "faked and forced" (Steven) and neither "natural" nor "believable" (Rory) animation. It was suggested that, not only would the animation be "hard to read" (Steven) but that the audience may interpret confusion (Patsy) or disgust (Tricia, Luke). Context and character were discussed for Seq.2 Tim.B, which was seen as being potentially appropriate for delayed or slowly developed feelings of anger, which contained more complexity and intensity. Table 6.5 shows the coding frequency for participant discussion of the major themes.

6.3.2.4 Neutral into fear

The trend of favouring initial upper face movement over lower face movement continued with animations of fear. Seq.2 Tim.A was discussed as useful for animating what appeared to be a sincere, genuine expression of fear which was also natural in appearance and practical to produce. Simultaneous movement was regarded as the next best choice by the majority of participants, with Seq.1 also generating "genuine fear" (Helen) and "a more emotional response" (Patsy). The latter EEC was not perceived to be as practical, however, but it was identified that the speed of facial movement would be appropriate to the emotion. Seq.3 Tim.A and Tim.B, while not regarded as inauthentic, were seen to be emotionally ambiguous choreographies. Seq.3 Tim.B in particular was highlighted as a confusing EEC, which was better suited to a "forced or faked emotion" (Steven).

Table 6.6: Themes coded for animations of fear after analysis of participant evaluation documents.

Choreographing 'Neutral into Fear					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	4/7	5/7	3/7	1/7	0/7
Creates inauthentic expression animation	1/7	0/7	2/7	1/7	3/7
Creates a clear expression of emotion	0/7	2/7	2/7	0/7	0/7
Creates an ambiguous expression of emotion	1/7	0/7	2/7	5/7	4/7
Discussed context	3/7	2/7	5/7	3/7	1/7
Discussed character	2/7	3/7	1/7	3/7	4/7
Considered an intuitive choreography	2/7	3/7	1/7	0/7	0/7
Considered a counterintuitive choreography	1/7	0/7	1/7	2/7	3/7
Considered a practical choreography	2/7	5/7	2/7	0/7	0/7
Considered an impractical choreography	1/7	0/7	1/7	2/7	1/7

6.3.2.5 Neutral into disgust

As indicated by Figure 6.2, simultaneous movement was the choreography which was discussed as the preferred choice by the majority of participants. However, there was less consistency across the more detailed comments for each of the EECs, and as such no one choreography stood out as the most or least authentic configuration. Similarly, the participants did not show majority consensus on the impact on expression clarity. This would suggest that the choreography of disgust is much more dependent on context as well as the subjective perspective of the animation practitioner. Context was discussed by many of the participants. Distinct timing choreographies were representative of a development of disgust, an insincere portrayal of disgust, or a mixture of disgust and anger (see Appendix XXVI). Overall, Seq.1 was regarded as the most practical choreography.

Table 6.7: Themes coded for animations of disgust after analysis of participant evaluation documents.

Choreographing 'Neutral into Disgust					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	3/7	1/7	2/7	2/7	3/7
Creates inauthentic expression animation	1/7	3/7	3/7	2/7	3/7
Creates a clear expression of emotion	2/7	1/7	0/7	0/7	1/7
Creates an ambiguous expression of emotion	0/7	1/7	2/7	0/7	2/7
Discussed context	0/7	2/7	4/7	0/7	4/7
Discussed character	1/7	3/7	2/7	0/7	3/7
Considered an intuitive choreography	3/7	0/7	0/7	1/7	0/7
Considered a counterintuitive choreography	0/7	2/7	2/7	0/7	0/7
Considered a practical choreography	6/7	0/7	0/7	2/7	1/7
Considered an impractical choreography	0/7	1/7	2/7	1/7	0/7

6.3.2.6 Neutral into surprise

Finally, animations of surprise were predominantly seen as effective using either Seq.1 or Seq.2 Tim.A, and ineffective using either Seq.3 Tim.A or Tim.B. Simultaneous movement was overwhelmingly seen as the most intuitive EEC for surprise – in that it “feels the most natural” (Helen) and was the choreography participants would “instinctively use” (Rory) – as well as being highly natural and sincere. Seq.2 Tim.A was regarded as a close second in terms of authenticity, with comments such as it being “also good to use” (Patsy) and “also a good choice” (Rory) indicating that Seq.1 was preferred by the majority. The choreographies that commenced with lower face movement were once again perceived as being unnatural and only appropriate for faked or exaggerated expressions of surprise (see Appendix XXVI comments).

Table 6.8: Themes coded for animations of surprise after analysis of participant evaluation documents.

Choreographing ‘Neutral into Surprise					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	6/7	5/7	1/7	1/7	0/7
Creates inauthentic expression animation	0/7	1/7	2/7	4/7	4/7
Creates a clear expression of emotion	2/7	1/7	0/7	0/7	1/7
Creates an ambiguous expression of emotion	0/7	0/7	0/7	1/7	1/7
Discussed context	2/7	3/7	4/7	1/7	2/7
Discussed character	0/7	1/7	3/7	1/7	2/7
Considered an intuitive choreography	7/7	1/7	0/7	1/7	0/7
Considered a counterintuitive choreography	0/7	0/7	2/7	0/7	2/7
Considered a practical choreography	5/7	2/7	0/7	0/7	0/7
Considered an impractical choreography	0/7	0/7	0/7	1/7	3/7

6.3.3 Choreographing emotional expression transition animations

In the study of expression transitions, interpretive phenomenological analysis of participant evaluation documents again revealed a degree of artistic majority regarding the role of choreography (see Figure 6.3). As before, Seq.3 Tim.B was generally seen as a weak EEC, although it was highlighted as the least effective choreography by more than 50% of participants for just three transitions; sadness into anger, anger into fear, and disgust into surprise. It was also identified as a potentially effective choreography for animations of surprise into happiness. For this transition, the two lower-face leading choreographies of Seq.3 Tim.A and Tim.B were backed by 6/7 participants, with only one participant stating a preference for an alternative. In addition, upper face peaking (Seq.2 Tim.B) was regarded as the weakest choreography by more than 50% of participants in two cases; surprise into happiness, and happiness into sadness. Here, the more even spread of EECs which were perceived as strong or weak demonstrates that the role of choreography is (in the animator's eyes) dependent on the context of the emotions being animated. In other words, although the previous findings suggested that Seq.2 Tim.A and Seq.3 Tim.B may be the strongest and weakest choreographies in general, the findings here demonstrate that the artistically perceived effect of choreography is in fact more complex. In the following sections, each of the transitions shall be discussed with reference to participant comments. As before, completed evaluation documents for this study are included as Appendix XXII while examples of the coded comments which substantiate the findings are listed in Appendix XXVI.

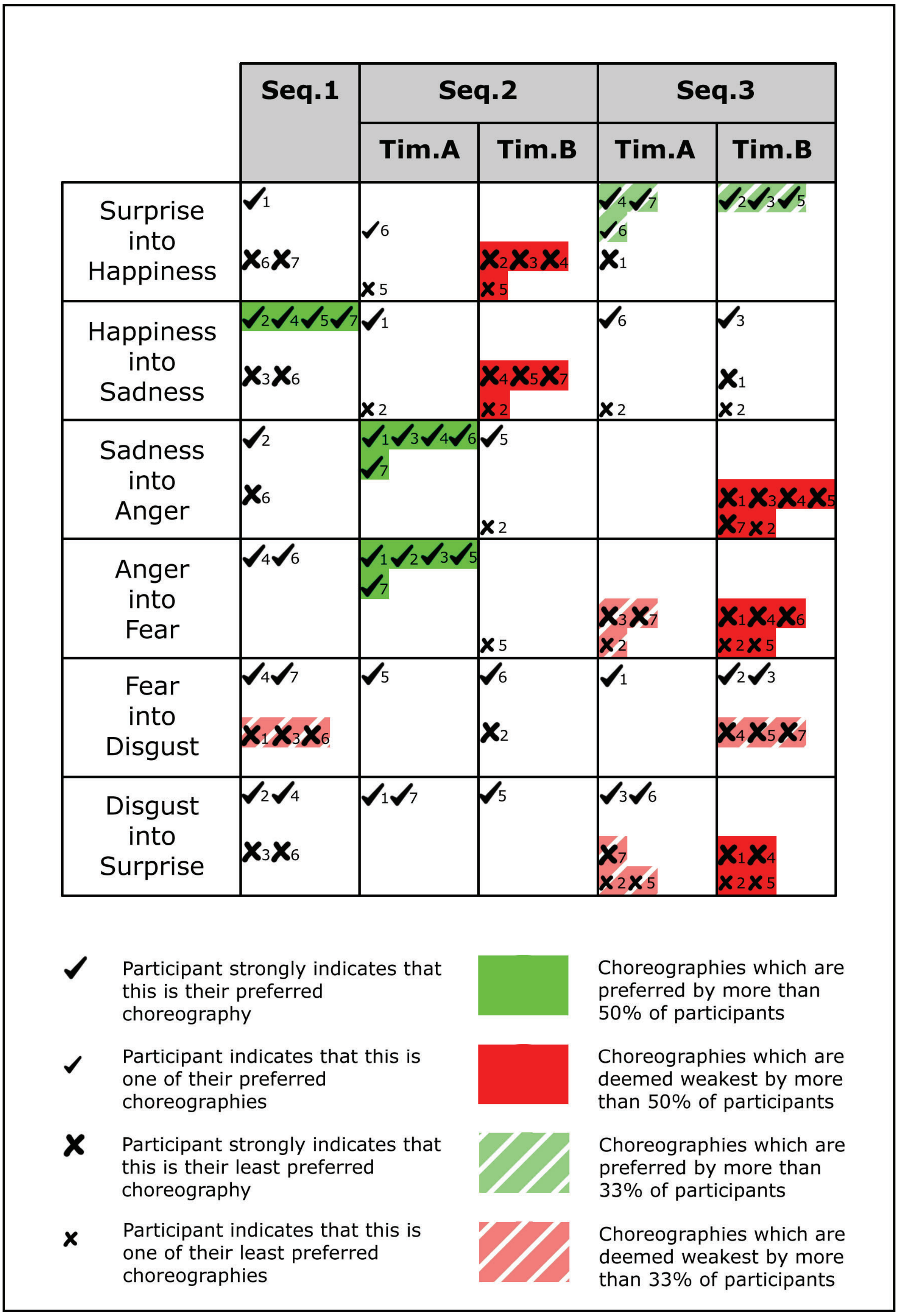


Figure 6.3: Final judgements by all participants regarding their most and least preferred choreographies when animating the six emotional expression transitions.

6.3.3.1 Surprise into happiness

The animation of surprise into happiness was one of the few instances where participants indicated a preference for lower-leading choreographies. Both Seq.3 Tim.A and Tim.B were discussed as being authentic; as the "most genuine change in emotion (Helen) and "as the most natural" (Rory). Of the alternative EECs, it was Seq.2 Tim.B – upper face peaking – that resulted in the most comments regarding inauthentic movement. The remaining choreographies sparked discussion on the potential context and character. However, there was little consistency between participant comments; Seq.1 was regarded as having either a specific context – as a faked expression (Helen) or reaction to a baby (Luke) – or no real context at all (Patsy, Wendy). Seq.2 Tim.A was seen as a choreography that would generate a more complex thought process, involving nervousness (Helen) or confusion (Tricia). Table 6.9 shows the frequency of major theme coding for surprise into happiness.

Table 6.9: Themes coded for animations of surprise into happiness after analysis of participant evaluation documents.

Choreographing 'Surprise into Happiness'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	1/7	2/7	2/7	6/7	4/7
Creates inauthentic expression animation	1/7	3/7	4/7	1/7	3/7
Creates a clear expression of emotion	0/7	0/7	0/7	1/7	3/7
Creates an ambiguous expression of emotion	0/7	1/7	0/7	0/7	1/7
Discussed context	4/7	3/7	2/7	3/7	1/7
Discussed character	2/7	4/7	3/7	3/7	3/7
Considered an intuitive choreography	1/7	1/7	0/7	3/7	3/7
Considered a counterintuitive choreography	1/7	2/7	2/7	0/7	0/7
Considered a practical choreography	3/7	2/7	0/7	1/7	1/7
Considered an impractical choreography	0/7	2/7	1/7	0/7	1/7

6.3.3.2 Happiness into sadness

The only area of majority consensus for the transition happiness into sadness was with the authenticity and artistically intuitive nature of simultaneous movement. Seq.1 was regarded as being “the most realistic” (Helen) and “most natural” (Rory) and was also the “most intuitive” (Luke) and “easiest to animate” (Tricia). Although there was little else said about the context of this particular EEC, the perceived reliability of Seq.1 over alternatives may suggest that more difficulty was found in animating effective transitions using more complex configurations. For instance, masking was identified as a specific context for Seq.2 Tim.B; the character could be “straining to hold back their sadness”, and the result “would work very well in this context” (Steven). Two participants indicated that careful animation could create an effective transition using Seq.2 Tim.B; that if it was “done really well, it can look pretty good” (Luke) and that “if the timing is perfect it could work well” (Helen). Context was also discussed for Seq.3 Tim.A which was generally regarded as being a potentially useful choreography within certain contexts; for example “struggling to cope with the situation” (Steven) or “if the character ends up crying at the end” (Luke). Table 6.10 summarizes the frequency of coding for animations of happiness into sadness.

6.3.3.3 Sadness into anger

As shown in Figure 6.3, there was a high level of consensus between participants when choosing Seq.2 Tim.A as the strongest and Seq.3 Tim.B as the weakest EECs for sadness into anger. All participants indicated that they

Table 610: Themes coded for animations of happiness into sadness after analysis of participant evaluation documents.

Choreographing 'Happiness into Sadness'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	4/7	2/7	3/7	1/7	1/7
Creates inauthentic expression animation	2/7	2/7	3/7	1/7	2/7
Creates a clear expression of emotion	0/7	1/7	1/7	0/7	0/7
Creates an ambiguous expression of emotion	1/7	0/7	1/7	0/7	1/7
Discussed context	3/7	1/7	4/7	4/7	3/7
Discussed character	1/7	2/7	5/7	3/7	2/7
Considered an intuitive choreography	4/7	1/7	1/7	1/7	0/7
Considered a counterintuitive choreography	0/7	0/7	1/7	0/7	0/7
Considered a practical choreography	2/7	1/7	0/7	1/7	1/7
Considered an impractical choreography	0/7	0/7	0/7	0/7	1/7

Table 6.11: Themes coded for animations of sadness into anger after analysis of participant evaluation documents.

Choreographing 'Sadness into Anger'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	1/7	7/7	2/7	2/7	0/7
Creates inauthentic expression animation	4/7	0/7	2/7	3/7	4/7
Creates a clear expression of emotion	2/7	2/7	1/7	1/7	0/7
Creates an ambiguous expression of emotion	0/7	0/7	2/7	3/7	4/7
Discussed context	2/7	4/7	2/7	1/7	0/7
Discussed character	5/7	3/7	4/7	2/7	4/7
Considered an intuitive choreography	1/7	3/7	0/7	0/7	0/7
Considered a counterintuitive choreography	1/7	0/7	0/7	0/7	0/7
Considered a practical choreography	3/7	2/7	1/7	1/7	0/7
Considered an impractical choreography	0/7	0/7	0/7	2/7	1/7

felt the former was authentic – that it "felt the most realistic" (Steven) and was "not performed" (Wendy). In terms of context, this choreography was seen to convey a development from sadness to anger with a clear cognitive process. Conversely, Seq.3 Tim.B was regarded as inauthentic and ambiguous. For the most part, the inauthenticity was rooted in a belief that the animation appeared to be an insincere expression. The resulting transition was unclear, in that participants believed that it would "confuse the audience" (Patsy) or look like fear (Patsy) or disgust (Tricia). Simultaneous movement was also viewed as an inauthentic EEC by the majority of participants, who again stated that the quick change across the face resulted in a transition that seemed fake or acted. Table 6.11 shows coding frequency for participant evaluation of sadness into anger.

6.3.3.4 Anger into fear

Similar to the response to animating sadness into anger, participants showed a high level of consensus regarding Seq.2 Tim.A as authentic and Seq.3 Tim.B as inauthentic for the anger into fear transition. Across all of the major themes, it was only the authenticity of these two EECs where participants showed agreement, with none of the other themes being coded for more than 3/7 of participant evaluation documents (see Table 6.12). Seq.2 Tim.A was regarded as an authentic transition as it was seen as a sincere reaction with natural, flowing movement. Individual participants also remarked that it was an artistically intuitive choice (Steven, Helen) and that the emotions were clearly staged (Patsy). As before, having the lower face peak before moving the upper face caused participants to interpret a faked or displayed emotion in their animation. The lack of initial upper face movement made later movement in the eyes appear excessively exaggerated (Helen) and generally created an animation which participants felt looked like staged emotions.

Table 6.12: Themes coded for animations of anger into fear after analysis of participant evaluation documents.

Choreographing 'Anger into Fear'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	3/7	5/7	3/7	0/7	0/7
Creates inauthentic expression animation	1/7	0/7	3/7	5/7	3/7
Creates a clear expression of emotion	0/7	2/7	1/7	0/7	0/7
Creates an ambiguous expression of emotion	1/7	0/7	0/7	2/7	3/7
Discussed context	3/7	3/7	3/7	2/7	0/7
Discussed character	1/7	2/7	2/7	3/7	1/7
Considered an intuitive choreography	1/7	3/7	1/7	1/7	0/7
Considered a counterintuitive choreography	0/7	0/7	1/7	1/7	1/7
Considered a practical choreography	1/7	1/7	1/7	0/7	0/7
Considered an impractical choreography	0/7	0/7	2/7	1/7	1/7

Table 6.13: Themes coded for animations of fear into disgust after analysis of participant evaluation documents.

Choreographing 'Fear into Disgust'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	1/7	1/7	0/7	2/7	5/7
Creates inauthentic expression animation	3/7	0/7	4/7	3/7	3/7
Creates a clear expression of emotion	1/7	0/7	0/7	2/7	2/7
Creates an ambiguous expression of emotion	2/7	2/7	1/7	0/7	2/7
Discussed context	2/7	3/7	4/7	1/7	3/7
Discussed character	2/7	4/7	3/7	2/7	5/7
Considered an intuitive choreography	1/7	0/7	0/7	1/7	1/7
Considered a counterintuitive choreography	1/7	0/7	2/7	0/7	1/7
Considered a practical choreography	3/7	0/7	0/7	0/7	1/7
Considered an impractical choreography	2/7	0/7	0/7	3/7	0/7

6.3.3.5 Fear into disgust

Figure 6.3 shows that there was little agreement between participants regarding their interpretation of choreographing fear into disgust as regards identifying the most effective EEC. When asked to identify which EECs they felt were strongest and weakest, no candidate emerged as the strongest, and there was limited agreement (3/7) that Seq.1 and Seq.3 Tim.B were the weakest configurations. However, closer analysis of participant evaluation documents revealed that a majority of participants actually saw Seq.3 Tim.B as being potentially authentic. This was the only EEC which was regarded as authentic by the majority of participants, who suggested that it was a "unique transition between fear and disgust" (Steven) which appeared fairly authentic and believable. Within this choreography, participants commented that other thoughts or emotions could also be occurring, making it a more complex (yet still authentic) animation. Alternatively, peaking with the upper face first (Seq.2 Tim.B) was interpreted as an inauthentic EEC as it "felt slightly unnatural" (Steven), "proved unnatural to watch" (Rory), and even appeared "very fake" (Helen). A context which called for a more deliberate development of emotion over time was identified as a potential scenario for this EEC.

6.3.3.6 Disgust into surprise

Lastly, participants found that Seq.1 and Seq.2 Tim.A were the most intuitive choreographies for disgust into surprise, in line with the study of neutral into surprise. However, as shown in Figure 6.3, neither was clearly identified as the strongest EEC. Analysis of participant comments showed that most participants felt that Seq.2 Tim.A was authentic, as it was a "reliable representation of the transition coupled with believable timing" (Steven) and "looked the most genuine" (Helen). An unexpected finding here was that, despite being perceived as intuitive, most participants actually found Seq.1 to be an inauthentic EEC for disgust into surprise. While three participants interpreted it as being fairly authentic, the remaining participants suggested that it "did not look natural" (Rory) and that it "looks like a meaningless transition" (Wendy).

Table 6.14: Themes coded for animations of disgust into disgust into surprise after analysis of participant evaluation documents.

Choreographing 'Disgust into Surprise'					
Themes coded (from 7 evaluation documents) 4/7 or greater highlighted in grey	**Seq1**	**Seq2 TimA**	**Seq2 TimB**	**Seq3 TimA**	**Seq3 TimB**
Creates authentic expression animation	3/7	4/7	3/7	2/7	0/7
Creates inauthentic expression animation	4/7	1/7	0/7	3/7	3/7
Creates a clear expression of emotion	1/7	1/7	0/7	0/7	0/7
Creates an ambiguous expression of emotion	0/7	0/7	1/7	1/7	1/7
Discussed context	3/7	1/7	3/7	2/7	2/7
Discussed character	2/7	3/7	3/7	3/7	3/7
Considered an intuitive choreography	4/7	4/7	1/7	0/7	0/7
Considered a counterintuitive choreography	1/7	0/7	0/7	0/7	1/7
Considered a practical choreography	1/7	1/7	2/7	1/7	0/7
Considered an impractical choreography	1/7	0/7	0/7	3/7	2/7

6.3.4 Discussion

With respect to the initial research questions, the phenomenological study of animation production provided evidence that the concept of emotional expression choreography could trigger a degree of intersubjective consensus when applied in practice. Firstly, the major themes identified after analysis of the practitioner-researcher's structured reflections were also coded within the data produced by research participants. In particular, both the practitioner-researcher and the participants showed an awareness of expression authenticity, clarity, context, and character when evaluating the outcome of choreographed animation. This indicated that the phenomenological study adequately replicated the studio-based research environment embraced by the practitioner-researcher in Chapter 4, as the participants were able to provide extensive details of their individual interpretations of EEC during and after practice.

Additionally, it was clear that a majority consensus was reached in most cases when stating the strongest and weakest choreographies. In general, it appeared as though upper face leading with overlapped timing was regarded as the best EEC, while lower face leading with distinct timing was regarded as the weakest EEC for most expressions and transitions. This was in line with the findings of the practitioner-researcher, who also discovered that leading with the upper face was most acceptable while the lower face peaking choreography was more difficult to apply. However, when each of the twelve expressions and transitions were examined individually, it was evident that the nature of the emotion being expressed modulated participant preferences. While upper face leading with overlapped timing (Seq.2 Tim.A) was generally strong, participants were more drawn to the lower face choreographies for animations of surprise into happiness. Furthermore, simultaneous movement (Seq.1) was preferred by the majority for disgust, surprise, and happiness into sadness.

By analysing participant evaluation documents, it became clear that a majority consensus (>50%) could be reached regarding the potential effect of EEC on authenticity, clarity, context, and character. Although there was fluctuation in personal interpretation of context and character, in most cases one or two EECs were identified by the majority as the most or least authentic. There was less agreement regarding the impact on expression clarity. Nevertheless, authenticity was perhaps the most important consideration, as it related directly to the idea that choreography could manipulate the believability of expressions. The results for participant interpretation of authenticity also allowed for a comparison with the

Table 6.15: A comparison of choreography interpretations between the participant group and the practitioner-researcher. Consistency between results is highlighted in yellow.

Animation	Most authentic: Practitioner-researcher	Most authentic: Participant majority	Least authentic: Practitioner-researcher	Least authentic: Participant majority
Happiness	Seq.3 Tim.A	Seq.3 Tim.A	Seq.2 Tim.B	Seq.2 Tim.B or Seq.3 Tim.B
Sadness	Seq.2 Tim.A	Seq.2 Tim.A	Seq.3 Tim.B	Seq.3 Tim.A or Seq.3 Tim.B
Anger	Seq.2 Tim.A or Seq.2 Tim.B	Seq.2 Tim.A	Seq.3 Tim.A or Seq.3 Tim.B	Seq.3 Tim.B
Fear	Seq.1 or Seq.2 Tim.A	Seq.1 or Seq.2 Tim.A	Seq.3 Tim.B	No majority
Disgust	Seq.3 Tim.A or Seq.3 Tim.B	No majority	No prediction	No majority
Surprise	Seq.1 or Seq.2 Tim.A	Seq.1 or Seq.2 Tim.A	Seq.3 Tim.B	Seq.3 Tim.A or Seq.3 Tim.B
Surprise into Happiness	Seq.3 Tim.A or Seq.3 Tim.B	Seq.3 Tim.A or Seq.3 Tim.B	Seq.1 or Seq.2 Tim.B	Seq.2 Tim.B
Happiness into Sadness	Seq.2 Tim.A	Seq.1	Seq.3 Tim.B	No majority
Sadness into Anger	Seq.2 Tim.A	Seq.2 Tim.A	Seq.3 Tim.A or Seq.3 Tim.B	Seq.1 Or Seq.3 Tim.B
Anger into Fear	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B	Seq.3 Tim.A
Fear into Disgust	Seq.2 Tim.A or Seq.3 Tim.A	Seq.3 Tim.B	Seq.2 Tim.B or Seq.3 Tim.B	Seq.2 Tim.B
Disgust into Surprise	Seq.1 or Seq.2 Tim.A	Seq.2 Tim.A	Seq.2 Tim.B or Seq.3 Tim.B	Seq.1

interpretations of the practitioner-researcher. As shown in Table 6.15, when contemplating the potential authenticity of EEC, there were high levels of consistency between the interpretations of the practitioner-researcher (discussed in Chapter 4) and the participant majority. Of twenty-four comparisons for the most and least authentic EEC for each of the twelve animations, only in six cases was no match found. These comparisons demonstrate not only that the qualitative findings of this study strongly support the views of the practitioner-researcher (lending weight to the validity of the performative findings), but also that animation practitioners are capable of extracting a consistent interpretation of the potential effects of EEC. Nevertheless, it is important to acknowledge that these findings are highly dependent on the IPA method and the specific context of the study, including the experience and expertise of the student animators who participated. As such, the findings are not suitable for generalisation, and would not necessarily be replicated in a future study.

In the next phase of qualitative research, the focus shifted to a study of audience perception.

6.4 A qualitative study of audience perception

The previous study looked to investigate the practice of student animators in order to determine whether fellow animators would show consensus regarding the role of EEC in facial animation. The results of this study bolstered the findings of the performative research (described in Chapter 4) by demonstrating that practice-based animation research could reveal elements of EEC for which there was intersubjective consensus. However, while the performative and phenomenological studies provided insight into the production of choreographed expression animations, the findings for audience perception of those animations (discussed in Chapter 5) were relatively incomplete. For instance, it was previously shown that the choice of EEC could significantly affect observer rating of authenticity. On the other hand, there were also instances where EEC selection did not appear to have a substantial effect on perception at all (for example, expression clarity). Additionally, a more nuanced measure – e.g. perception of context – was not practical to implement in the experimental research. The positivistic studies of Chapter 5 therefore showed that EEC can alter the way in which an audience interprets emotional expression animations, but they could not explain in detail what the audience interpretation might be. As a result, a qualitative study of audience perception was planned in order to explore the perceived nature of the choreographed animations. It was hoped that the findings of this study would substantiate and elaborate the findings of the studies described in Chapter 5, in much the same way that the phenomenological study of animation production elaborated on the findings of the performative research.

6.4.1 Research questions

As with the experimental studies described in sections 5.2 and 5.3, the current qualitative study was conducted on the back of performative research into the creative production of choreographed expression animations. The sixty animations used in the two experimental studies were used in the current study, so the qualitative findings of the study could be compared to the practitioner-researcher's predictions discussed in Chapter 4 as well as the experiments discussed in Chapter 5. The following research questions were posed at the commencement of the study:

I. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect how audiences interpret the emotions or feelings of a character?

II. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect how audiences interpret the thought process of a character?

III. Do creatively-applied emotional expression choreographies (based on the sequence and timing of upper and lower facial regions) affect how audiences interpret the possible context of emotional expression animations?

No firm predictions were made regarding the outcome of the study, again due to the exploratory nature of qualitative research. However, it was expected that there would be a degree of overlap between the informed predictions of the practitioner-researcher and the findings of the current study. It was also expected that the findings would provide additional supporting information to corroborate the findings of the positivist experiments discussed in Chapter 5. It was not predicted that there would be consensus regarding the exact contextual nature of animations, either within or between participant groups[1]. Instead, it was expected that participants would provide a snapshot of possible audience interpretations of animation, allowing the researcher to

[1] Indeed, the method which was ultimately selected for the current study – focus groups – is not ideal for establishing consensus or generalizing findings to a wider population (see Krueger and Casey, 2009).

put together a more complete picture of the effects of emotional expression choreography.

6.4.2 Method

The chosen method for the qualitative study of audience perception was the use of focus groups. This qualitative method, typically applied in marketing research, has been highlighted as an underused yet practical approach to qualitative data collection that could compliment more typical social science research methods (Basch, 1987; Morgan, 1998; Vaughn, Schumm and Sinagub, 1996). The overview of the focus group method provided by Krueger and Casey (2009) was used as the principal guide to the design, facilitation, and transcript analysis of the focus groups. The multiple-category design (Krueger and Casey, 2009, p 26) was adopted in order to accommodate three identified participant types (see 6.4.2.1). The researcher acted as the facilitator (or moderator) of every focus group session. The role of the facilitator was to control the pace of the focussing exercise and to ensure that all participants were given a chance to be involved in the discussion. Video and audio recording equipment were used to capture the focus group sessions, and the facilitator also took observational notes to aid in transcription and analysis. Researcher neutrality was strongly acknowledged and, although it was not feasible to make use of a larger team of researchers or group facilitators within the constraints of the current study, the systematic procedure taken for data collection, handling, analysis, and presentation ensured a high level of study reliability. Due to the nature of focus group research, the findings of the study were never intended to generalize audience interpretation of EEC. Instead, the findings were intended to offer a more in-depth view of potential audience interpretation.

6.4.2.1 Sample and site of research

As discussed, three types of participants were identified for the purposes of the focus group sessions. These participant types were labelled as General (not from a psychology or visual arts background), Psychology (participants educated in psychology), and Visual Arts (educated in art practice, specifically animation). The selection of three participant types was not explicitly designed to allow a comparison between groups; instead, the goal was to collect data from participants who would have a broad range of experience studying or generating facial expressions. Participants had not previously taken part in the experiments discussed in Chapter 5, to ensure that they had no understanding of the EEC concept. In order to recruit participants for the psychology and visual arts types, emails were sent to students of the School of Social and Health Science and the Institute of Arts, Media and Computer Games at the University of Abertay. Flyers were distributed and social networking sites such as Twitter and Facebook were used in order to recruit participants for the General participant type.

All focus group sessions took place in the HIVE laboratory at the University of Abertay (see Figure 6.4). Participants sat around a table in front of back projected screens, upon which the animations and task questions were displayed. The facilitator sat at one end of the table slightly apart from

Figure 6.4: The HIVE laboratory at the University of Abertay, site of the focus groups. The images in the bottom row show focus groups of general, psychology, and visual arts participant types.

the focus group participants, and operated the computer used to display the animations using a wireless keyboard. A single HD camcorder (positioned so as to capture all of the participants sat around the table) and audio recorder were used to capture the discussion for later transcription.

6.4.2.2 Focussing exercise

Prior to the main focussing exercise, participants were asked to read and sign the informed consent document and complete a short questionnaire (Appendix XXVII). The questionnaire was used to assess individual participant's confidence in expression identification, familiarity with studies of nonverbal communication, the process of 3D animation, and traditional principles of animation. The questionnaire also tasked participants with identifying emotions displayed in twelve images. The twelve images were produced using the Emotional Avatars rig, and were intended to show each of the six universal expressions at two levels of emotional intensity. Once all participants had arrived and had completed the informed consent and questionnaire, the facilitator gave the participants a full briefing on the nature of the focus group, including recording methods, the role of the facilitator, and the tasks the participants will be asked to complete (see Appendix XXVII).

The main focussing exercise was developed based on one of Krueger and Casey's suggested activity-based questioning routes, which concentrates on "choosing among alternatives" (Krueger and Casey, 2009, p 45). Although their proposed focussing exercise is designed so that participants are asked to review and select one option from a range of three to five alternatives, a focussing exercise which centred on the activity of viewing and commenting on a range of ideas was deemed an appropriate foundation for a qualitative study of animation perception. The alternatives which were shown to participants were the sixty choreographed emotional expression and expression transition animations developed as part of animation studies 1 and 2 (see sections 4.3 and 4.4). This meant that the participants viewed five alternate choreographies (Seq.1, Seq.2 Tim.A, Seq.2 Tim.B, Seq.3 Tim.A, and Seq.3 Tim.B) applied to six emotional expressions (happiness, sadness, anger, fear, disgust, and surprise) and to six expression transitions (surprise into happiness, happiness into sadness, sadness into anger, anger into fear, fear into disgust, and disgust into surprise). However, rather than being asked to chose one option from the five alternatives for each expression and expression transition, participants were instead asked to interpret and comment on each animation, without being made aware of the five EEC alternatives. This decision was made because the goal was to generate qualitative data on observer perception rather than to definitively identify one choreography preference for each emotional expression or transition.

To achieve this, the sixty animations were entered into Adobe Flash and presented in a randomized order in each focus group session. Each video was looped repeatedly for a period of up to two minutes while the participants discussed what they interpreted from the animation. Underneath the video, three prompting questions were displayed to remind the participants of the group task. The questions were as follows:

1. What is the character feeling?
2. What is the character thinking?
3. In what context might a person express themselves in this way?

Participants were initially given a practice session which contained four acted expression videos. At this point, the facilitator demonstrated the format of the focussing exercise, discussed the three questions which the participants were being asked to address, and emphasized that everyone should be given an opportunity to voice their opinion on each video. Participants were then asked to comment on and discuss the remaining acted videos. After the practice session, the main task commenced. Each focus group session were shown the sixty animations in blocks of fifteen, with an approximate three minute break between blocks. The facilitator acted primarily as the pace setter, and operated the Adobe Flash application by loading and announcing each new video. A stop watch was used by the facilitator to ensure that each video was discussed for an average of ninety seconds, although he used his judgement to allow more or less time if useful data was clearly being collected or if there was little or no discussion. It was crucial that each video was timed and that a 2 minute duration was enforced in the majority of cases in order to keep the overall duration of the session under two hours.

6.4.2.3 Focus groups

Five focus group sessions were held in total. As the intention was to collect data from participants with a range of experience rather than compare participant types, five groups was deemed sufficient as saturation[1] was achieved after the fifth group. The focus groups consisted of between three and six participants[2], with a total of 26 participants across all sessions (9 female, 17 male, median age of 24.5, age range 17-43). As described earlier, each focus group session was facilitated by the researcher, and sessions typically lasted approximately ninety minutes. Table 6.16 shows a breakdown of the individual participants for each focus group session. Coded transcripts of all six sessions are provided in Appendix XVIII, which groups the discussions by emotional expression choreography for ease of comparison.

[1] The point at which no more new information appears to emerge from group discussion, see Krueger and Casey (2009, p 21).
[2] Although focus groups typically consist of 6-10 members (Krueger and Casey, 2009), pilot testing revealed that larger groups were unfeasible for this study, primarily because the participants had to discuss sixty animations within a maximum 2 hour period. As the goal of the study was to capture the audience's instant reactions to animation and to encourage short discussions about the meaning of expressions, smaller groups of 3-6 participants were found to be more suitable for the exercise.

Table 6.16: Breakdown of participants for each focus group session.

Group	A	
Type	General	
Participant	Sex	Age
1	M	25
2	M	37
3	M	31
4	M	26
5	M	30
6	M	25

Group	B	
Type	Psychology	
Participant	Sex	Age
1	F	43
2	F	33
3	M	32

Group	C	
Type	Psychology	
Participant	Sex	Age
1	M	17
2	F	18
3	F	40
4	F	35
5	F	40

Group	D	
Type	Visual Arts	
Participant	Sex	Age
1	M	30
2	F	21
3	M	22
4	M	23
5	M	24
6	M	23

Group	E	
Type	Visual Arts	
Participant	Sex	Age
1	F	22
2	F	22
3	M	21
4	M	21
5	M	21
6	M	23

6.4.2.4 Analytical procedure and data reliability

The procedure used to guide the analysis of focus group data followed Krueger and Casey's (2009) recommended process; that the analysis should be purpose driven, systematic, verifiable, sequential, and continuous. The purpose of the focus group study was to address the three research questions posed in section 6.4.1 – to explore how EEC affected an audience's ability to interpret expressions, to interpret the character's thought process, and to imagine potential contexts. As such, coding of transcript data was explicitly focussed on four broad themes; emotion identification, authenticity, character, and context[1]. Systematic analysis of data involved examination of each of these themes in turn grouped by emotional expression or expression transition (see Appendix XXVIII for the analytical steps taken). Verification was achieved through the establishment of a trail of evidence, including moderator notes and coded transcripts (see Appendix XXVIII). Sequential and continuous analysis was addressed by initiating data analysis immediately following the conclusion of each group (by reviewing field notes), reviewing the video recordings, reading transcripts, and finally coding transcripts using the established themes.

6.5 Data analysis of the qualitative study of audience perception

Firstly, evaluation of questionnaires demonstrated that the individual participants had a broad range of experience regarding non-verbal communication and animation production. In the majority of cases, participants were able to assign emotional descriptions to the still images of facial expressions which matched or approximated the intended emotion. As such, it could be proposed that the participants were capable of accurately interpreting emotional expressions displayed on the facial rig used to produce the animations. The following interpretations of participant comments were developed following the analytical procedure detailed in Appendix XXIX.

[1] These major themes and their associated meaning units were derived from the earlier phenomenological study of animation production, and are detailed in Appendix XXVII.

6.5.1 Audience interpretation: choreographed emotional expression animations

In the following sections, summaries of participant observations are presented for each of the six emotional expression animations. Both the coded transcripts and analysis documents contained in Appendices XXVIII and XXIX detail the evidence trail which led to the eventual conclusions regarding audience; identification of emotion, perception of authenticity, perception of thought process, and interpretation of context.

6.5.1.1 Neutral into happiness

All animations of happiness were broadly identified as being inauthentic, faked, or unnatural. This may be due to a stronger, natural ability to detect minor flaws in the presentation of joy expressions. Nevertheless, the animations which led with initial lower face movement (Seq.3 Tim.A and Tim.B) received the most comments regarding genuine or natural expressions, while simultaneous movement (Seq.1) was clearly the least authentic. Happiness was readily identified across the board, albeit with a degree of mixed emotion; for instance, simultaneous movement appeared pained or tense, while lower face leading (Seq.3 Tim.A) was seen as happiness mixed with embarrassment, cheekiness, wickedness, and puzzlement. In terms of character thought process and context, simultaneous movement (Seq.1) appeared as a false display, suitable as a social smile. Upper face leading with overlapped timing (Seq.2 Tim.A) was more representative of a memory of or suppression of happiness suited for a

Table 6.17: Summary of audience interpretation of neutral into happiness animations.

Audience Interpretation of Neutral into Happiness				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Happiness. Potentially pained or tense.	Inauthentic, faked.	False display of happiness *(few comments).*	Social smile in response to an uncomfortable situation.
Seq.2 Tim.A	Happiness.	Predominantly faked or unnatural. Potentially authentic.	Memory or suppression *(few comments).*	Frustration, boredom, uncomfortable.
Seq.2 Tim.B	Not happiness.	Predominantly faked or unnatural. Potentially authentic.	Evil, smarmy, cheeky character types.	Ulterior motives, envy, hate, expected to be happy.
Seq.3 Tim.A	Happiness. Potentially embarrassed, puzzled.	Could be perceived as either genuine or faked.	Masked or staged expressions.	*(Insufficient comments)*
Seq.3 Tim.B	Happiness. Potentially pride, confusion.	Could be perceived as either genuine or faked.	Thinking *(few comments).*	Observation of or participation in an event that triggers happiness.

context where frustration or boredom can come into play. Upper face leading with distinct timing (Seq.2 Tim.B) appeared cheeky, controlled, or even evil, appropriate to a scenario where happiness is perhaps expected but feelings of envy or hate emerge. Lower face leading with overlapped timing (Seq.3 Tim.A) was interpreted as a controlled or staged happiness, while context was difficult to establish. Finally, lower face leading with distinct timing was seen as an expression which conveyed a deeper thought process, suited to a context which elicits a genuine feeling of joy. These findings are summarized in Table 6.17.

6.5.1.2 Neutral into sadness

All five animations of sadness were clearly identified as the intended emotion with little confusion, supporting the earlier experimental findings (see Chapter 5). As shown in Table 6.18, simultaneous movement (Seq.1) was neither clearly authentic nor inauthentic, with a limited thought process. The context here was strongly associated with bad or upsetting news, most likely received suddenly and unexpectedly. Upper face leading with overlapped timing (Seq.2 Tim.A) was potentially genuine (with one supporting comment), and was seen to be representative of a character controlling or holding back an emotion in a context where bad news is revealed gradually. Upper face leading with distinct timing (Seq.2 Tim.B) was more clearly genuine, with an apparent look of reflection or dwelling on a memory. Again, this was seen as suitable to a scenario where bad news is revealed slowly, but also where the emotional stimulus is internally generated. Lower face leading with overlapped timing (Seq.3 Tim.A) was regarded as an inauthentic expression where the character looked on the verge of tears. The context here was interpreted as being a form of let down, for instance the loss of a job or not being invited out with friends. Lower face leading with distinct timing (Seq.3 Tim.B) received the most comments regarding it being a faked or unnatural expression, perhaps due to the character holding back or masking their emotion. It was proposed that the character may be seeking to manipulate the situation by expressing false sadness. In context, a slower realisation of sadness was suggested, with display rules applied; for example trying to maintain composure at a funeral or after failing a test.

Table 6.18: Summary of audience interpretation of neutral into sadness animations.

Audience Interpretation of Neutral into Sadness				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Sadness.	Potentially authentic or inauthentic *(few comments).*	Limited thought process *(few comments).*	Reaction to sudden sad news or observation of a sad event.
Seq.2 Tim.A	Sadness. Potentially concerned.	Potentially genuine *(few comments).*	On the verge of tears, holding back.	Revelation of sad news, emotion develops gradually.
Seq.2 Tim.B	Sadness. Potentially pride.	Authentic, genuine.	Reflection, memory.	Slowly revealed sad news or sadness triggered by reflection.
Seq.3 Tim.A	Sadness. Potentially despondent.	Inauthentic, expressionless.	About to cry.	A let down.
Seq.3 Tim.B	Sadness.	Inauthentic, emotionless, faked.	Masking emotion / holding back, wanting their own way.	A developing situation where the character is let down or made upset, but where social display rules apply.

6.5.1.3 Neutral into anger

There were few comments regarding the authenticity of choreographed expressions of anger, with Seq.3 Tim.B being the only configuration to be regarded as inauthentic by participants. Additionally, other emotions were observed, mixed with anger, for all five choreographies. As shown in Table 6.19, simultaneous movement (Seq.1) was seen as confusion, anger, and disgust, most likely a reaction to an event or statement which is not explicitly hostile. Seq.2 Tim.A conveyed a range of emotions to participants, appeared as a less threatening and more frustrating expression than alternatives, and was deemed appropriate to a scenario which may trigger disbelief. Seq.2 Tim.B appeared to represent anger and frustration, while the character seemed to be questioning the situation. The context here was more closely associated with a feeling of anger in response to a negative stimulus (for instance an insult or observation of violence), building up to focussed anger. Again, Seq.3 Tim.A conveyed a thought process that participants identified as inquisitive, this time leading to an emotional response of anger, surprise, and disappointment. The scenarios discussed suggested a build up of anger over time, precipitated by a shocking or unexpected event and leading to rage or even violence. Finally, Seq.3 Tim.B was observed as containing anger, sadness, disbelief, and disappointment. The character appeared to be processing information after being exposed to an antecedent event which initially caused feelings of sadness or confusion, but which builds up into anger.

Table 6.19: Summary of audience interpretation of neutral into anger animations.

Audience Interpretation of Neutral into Anger				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Anger, confusion. Potentially disgust.	Potentially faked *(one comment).*	Potentially staged *(one comment).*	A confused or disgusted reaction to an observed event.
Seq.2 Tim.A	Anger, sadness, confusion. Potentially contempt, disappointment.	*(no comments).*	Questioning, non-threatening.	A disbelief reaction leads into angry frustration or disagreement.
Seq.2 Tim.B	Anger, frustration. Potentially disgust, disbelief.	*(no comments).*	Questioning.	Observing or hearing something which induces a development of focussed anger.
Seq.3 Tim.A	Anger, surprise, disappointment. Potentially sad, disgust.	*(no comments).*	Questioning, inquisitive.	Shocking or frustrating external stimulus, leads to anger / violence.
Seq.3 Tim.B	Anger, sadness, disappointment/ Potentially disbelief, disgust.	Inauthentic.	Processing information.	Gradually revealed upsetting / frustrating news.

6.5.1.4 Neutral into fear

There were few comments regarding the authenticity of fear animation, except in the case of Seq.3 Tim.B which was again regarded as being inauthentic or unnatural (see Table 6.20). Simultaneous movement (Seq.1) was regarded as a mix of fear, disbelief, and disgust which may work in a wide range of contexts where a threat is encountered or observed. Upper face leading with overlapped timing (Seq.2 Tim.A) was seen as fear, surprise, and disbelief, as the character initially reacted to a frightening encounter or bad news before developing a stronger feeling of terror or alarm. Seq.2 Tim.B was identified as fear, sadness, and confusion, where the character is slowly taking in information and is unsure how to react. This EEC could be linked to observation of an unfolding event which gradually becomes more horrific, with examples such as the September 11th terrorist attacks and a car crash given. Lower face leading with overlapped timing (Seq.3 Tim.A) conveyed fear, sadness, confusion, and even a smile to participants. This EEC created a thought process which appeared to show that the character was caught off guard, while comments on the context indicated an element of shock or surprise following the observation of a horrific event or a frightening announcement. Seq.3 Tim.B was more problematic for participants, who observed fear and sadness predominantly, but who were unable to discern any clear thought process. The proposed context here was the development of a mildly scary situation.

Table 6.20: Summary of audience interpretation of neutral into fear animations.

Audience Interpretation of Neutral into Fear				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Fear, disbelief, disgust. Potentially surprise.	*(Insufficient comments)*	Disbelief or shock.	Generic 'fear' contexts; observation of and reaction to a threat or bad news.
Seq.2 Tim.A	Fear, surprise, disbelief. Potentially surprise, sad.	Potentially genuine *(few comments).*	Reacting to a fear stimulus, realisation and development of terror.	Generic 'fear' contexts; observation of and reaction to a threat or bad news.
Seq.2 Tim.B	Fear, surprise, sadness, disbelief.	*(Insufficient comments)*	Taking in information.	Observation of an unfolding, horrific event.
Seq.3 Tim.A	Fear. Potentially a smile, sadness, confused.	Inauthentic, unnatural *(few comments).*	Caught off guard, shocked.	Presented with a shocking event or announcement, develops into fear.
Seq.3 Tim.B	Fear, sadness. Potentially a smile.	Inauthentic, unnatural.	*(Insufficient comments)*	Potentially a development of a mildly scary situation.

6.5.1.5 Neutral into disgust

Few comments were offered on the authenticity of disgust animations. Disgust was clearly identified as the core emotion in three cases; Seq.1, Seq.3 Tim.A, and Seq.3 Tim.B. In all other cases, other emotions such as anger, confusion, sadness, and even happiness were recognised alongside disgust (see Table 6.21). For simultaneous movement (Seq.1) participants interpreted that the character perceived the situation as mundane or predictable, while the context itself could relate to either a situation or person which is perceived as disgusting but is expected. Seq.2 Tim.A led to a range of interpretations for thought process, while the suggested contexts would imply a stronger feeling of contempt towards a distasteful situation or person. This context was also applicable for Seq.2 Tim.B, where the contempt for another individual was more clearly apparent from participant comments.

Seq.3 Tim.A, on the other hand, showed a character which was perceived to feel uncomfortable in reaction to a more prototypical range of pure disgust triggers, including observation of or smelling disgusting stimuli. Similar results were found for Seq.3 Tim.B which showed a character which was interpreted as being disagreeable and displeased by a situation which caused an increasing feeling of disgust.

6.5.1.6 Neutral into surprise

Finally, animations of surprise were generally interpreted as being expressions of surprise with one other emotion; happiness in three cases,

Table 6.21: Summary of audience interpretation of neutral into disgust animations.

Audience Interpretation of Neutral into Disgust				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Disgust. Potentially anger.	*(Insufficient comments).*	No time to think, event perceived as mundane or nothing special.	An "every day disgust". Suitable to a predictable or expected scenario.
Seq.2 Tim.A	Disgust, anger. Potentially sadness, confusion, happiness.	Potentially inauthentic *(few comments).*	Questioning, controlled, cunning *(few comments).*	A reaction to a distasteful or inappropriate comment or situation. Contempt and disgust.
Seq.2 Tim.B	Disgust, anger. Potentially sadness, confusion, happiness.	*(Insufficient comments).*	Distrustful, disagreeable, concentrating, hostile.	Suitable to a scenario where contempt is triggered; disgust and anger towards the actions of another person.
Seq.3 Tim.A	Disgust. Potentially anger	*(no comments).*	Thought process apparent; uncomfortable, hostile.	A range of pure disgust reaction scenarios; observation, smell.
Seq.3 Tim.B	Disgust. Potentially anger.	Authentic, genuine *(few comments).*	Displeased, dislike, disagreeable.	A range of pure disgust reaction scenarios; observation, smell. Disgust grows.

and fright for simultaneous movement (see Table 6.22). Seq.1 was seen as authentic and genuine, and as an appropriate instant reaction for a wide range of surprise-inducing scenarios. Seq.2 Tim.A was regarded as an authentic, slightly positive expression, although some participants indicated that they felt it was an exaggerated or staged expression. Seq.2 Tim.B was potentially inauthentic with a more apparent thought process, setting up what appeared to be a delayed reaction to a shocking stimulus. Both lower face choreographies (Seq.3 Tim.A and Tim.B) were seen as potentially fake, yet applicable to a wide range of contexts where a surprising event is observed or news is delivered.

Table 6.22: Summary of audience interpretation of neutral into surprise animations.

Audience Interpretation of Neutral into Surprise				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Surprise. Potentially fear or disbelief.	Authentic, genuine.	No time to think.	Generic surprise contexts where the shock is immediate and uncontrolled.
Seq.2 Tim.A	Surprise, happiness.	Authentic, genuine. Potentially inauthentic.	Contrary to comments on it being authentic, may appear as if the character is overstating the emotion.	Applicable primarily to positive surprise events; observation or news.
Seq.2 Tim.B	Surprise. Potentially happiness, excitement.	Inauthentic. Potentially genuine.	Thought process more apparent, mulling it over, processing information.	Delayed reaction of surprise, likely an observed or heard event that causes shock.
Seq.3 Tim.A	Surprise, happiness. Potentially anger.	*(Insufficient comments).*	Unexpected, disbelief.	Generic surprise contexts; surprise news, surprise observation
Seq.3 Tim.B	Surprise. Potentially happiness.	Inauthentic, faked, unnatural.	Unexpected encounter or news.	Generic surprise contexts; surprise news, surprise observation

6.5.2 Audience interpretation: choreographed emotional expression transition animations

In the following sections, summaries of participant observations are presented for each of the six emotional expression transitions. As before, both the coded transcripts and analysis documents contained in Appendices XXVIII and XXIX detail the evidence trail which led to the eventual conclusions regarding audience; identification of emotion, perception of authenticity, perception of thought process, and interpretation of context.

6.5.2.1 Surprise into happiness

For all variations except upper face leading with overlapped timing (Seq.2 Tim.A), surprise and happiness were clearly identified, typically with potential elements of relief or disappointment. Participant comments generally indicated that most of the EECs were inauthentic to a degree; Seq.1, Seq.2 Tim.A and Seq.2 Tim.B all proved to be primarily inauthentic animations, while the lower face choreographies were seen as more authentic. In particular, lower face leading with distinct timing (Seq.3 Tim.B) was the only EEC which was predominantly authentic. For all choreographies, potential thought processes were suggested by participants, as shown in Table 6.23. Variation here suggested that manipulation of choreography could not only affect authenticity, but also the nature of the character; for example Seq.2 Tim.A appeared “subdued” while Seq.3 Tim.B showed a higher level of cognitive appraisal. Additionally, variation in context was perceived; while simultaneous movement (Seq.1) could be widely applicable to appropriate scenarios, more specific situations were suggested for the alternatives. For instance, a context of staged happiness could suit upper face leading with distinct timing (Seq.2 Tim.B).

6.5.2.2 Happiness into sadness

Happiness and sadness were the two emotions clearly identified by participants across all five choreographies, with other potential expressions (including fear and disappointment) also picked up (see Table 6.24). Variation in perceived authenticity was observed, with the most interesting example

Table 6.23: Summary of audience interpretation of surprise into happiness animations.

Audience Interpretation of Surprise into Happiness				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Surprise, happiness. Potentially relief.	Inauthentic. Potentially genuine.	Novelty, contentment.	Generic happy-surprise situations.
Seq.2 Tim.A	Difficult to read. Potentially happiness, surprise, relief, contempt, not happy.	Inauthentic, faked, unnatural.	Subdued, can't be bothered.	A situation where an unwanted surprise is experienced, potentially a generic happy-surprise context.
Seq.2 Tim.B	Surprise, happiness. Potentially sadness, disappointment, relief.	Predominantly inauthentic, faked. Potentially genuine.	Thought process shown, suspicious, contentment, displayed emotion.	A situation where the happiness is not completely genuine; underlying disappointment, feeling that they are being tricked.
Seq.3 Tim.A	Surprise, happiness. Potentially relief.	Could be perceived as either genuine or faked.	Relief, satisfaction, sarcasm.	Generic happy-surprise context. May be suited to a context where the character is duped or tricked, or is relieved.
Seq.3 Tim.B	Surprise, happiness. Potentially relief.	Predominantly authentic, genuine. Potentially inauthentic	Thought process shown, cognitive appraisal.	Contexts where initial surprise gradually develops into genuine happiness.

being upper face leading with distinct timing (Seq.2 Tim.B). Here, participants commented that it was the happy expression in particular which was inauthentic, while the sadness appeared genuine. This fed into the character and context of the choreography; that this was an example of sadness masked by happiness (the held smile), while the animation would specifically suit a situation where the character wishes to disguise their true feelings. This concept was identified for lower face peaking (Seq.3 Tim.B), which may additionally convey a memory or a feeling of heartbreak.

Table 6.24: Summary of audience interpretation of happiness into sadness animations.

Audience Interpretation of Happiness into Sadness				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Happiness, sadness. Potentially fear.	Could be perceived as either genuine or faked.	Sorry, masked / displayed emotion.	Likely a tragic change in events, triggering a strong shift in emotion.
Seq.2 Tim.A	Happiness, sadness. Potentially disappointment.	Authentic, genuine.	Remembering, thinking	A scenario where the character recalls a sad event, or where unexpected sad news is revealed.
Seq.2 Tim.B	Happiness, sadness. Potentially disappointment, confusion, regret, concern.	Faked happiness, genuine sadness.	Masking sadness with happiness, potentially confusion.	A context where it would be beneficial to mask true sadness with faked joy.
Seq.3 Tim.A	Happiness, sadness. Potentially concern, worry, confusion, fear, pity.	Potentially authentic *(few comments).*	Processing information, displayed emotion.	Suited to a situation where something which was expected to be good is revealed as bad; processing sad news.
Seq.3 Tim.B	Happiness, sadness.	Potentially fake happiness, potentially genuine sadness *(few comments).*	Masking sadness with happiness, memory, heartbreak.	Appropriate for scenarios where it would be beneficial to mask true sadness with faked joy; for instance, failing to get a job

Table 6.25: Summary of audience interpretation of sadness into anger animations.

Audience Interpretation of Sadness into Anger				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Sadness, anger. Potentially confusion, disgust.	*(Insufficient comments).*	Caught off guard, realisation, dealing with the situation by appearing menacing.	Applicable to generic sad-anger contexts; realisation or development.
Seq.2 Tim.A	Sadness, anger. Potentially surprise, disbelief, confusion, disgust.	*(No comments).*	Thinking moment, processing information.	Upsetting news twists or develops into bad, anger-inducing news.
Seq.2 Tim.B	Sadness, anger. Potentially disbelief.	*(No comments).*	Cognitive appraisal. Potentially thoughts of betrayal, being scorned, or denial.	Suited to a situation where sad and then bad news is revealed gradually over time; a reaction to something being explained to the character.
Seq.3 Tim.A	Sadness, anger. Potentially shock, disbelief, confusion.	*(No comments).*	Potentially a moment of realisation or annoyance, thoughts of revenge or angry disbelief.	Appropriate in a sad situation where another person's conversation or ineptitude triggers annoyance and then anger.
Seq.3 Tim.B	Sadness, anger, confusion. Potentially surprise, disbelief, worry, mixed emotion.	Potentially inauthentic *(few comments).*	Trying to work something out or understand something.	A slow realisation developing into hatred.

6.5.2.3 Sadness into anger

For this transition, few comments were made regarding the authenticity of the animation, with only lower face leading with distinct timing (Seq.3 Tim.B) coming across as potentially inauthentic. The two intended emotions were clearly identified in all cases, with an expression of confusion also apparent in Seq.3 Tim.B. As shown in Table 6.25, most EECs were associated with a clear thought process, which typically involved a realisation or the processing of information. More specific thoughts – such as betrayal and denial for Seq.2 Tim.B – were suggested. In terms of context, simultaneous timing was regarded as being generally applicable to appropriate contexts, while the distinct timing choreographies suggested a more gradual development and build up of anger.

6.5.2.4 Anger into fear

For animations of anger into fear, the two core emotions were easily identified by participants in all cases, while surprise was frequently mentioned as a tertiary emotion (see Table 6.26). This was particularly apparent for simultaneous movement (Seq.1), which was attributed to contexts where an unexpected or shocking event triggered the experience of fear. Upper face leading with overlapped timing (Seq.2 Tim.A) was the only EEC to be regarded as potentially genuine, and, along with lower face leading with overlapped timing (Seq.3 Tim.A), it was suggested that the character was appraising the development of events. In context, these two choreographies may be suited to a situation where the tables are turned on the character, shifting from a position of power to weakness. Again, the distinct timing choreographies “Seq.2 and Seq.3 Tim.B) were regarded as being associated with a more gradual appraisal.

6.5.2.5 Fear into disgust

A range of emotions were observed for choreographies of fear into disgust. Although the intended emotions were identified in all cases, only with the lower face choreographies were they clearly identified over alternative

Table 6.26: Summary of audience interpretation of anger into fear animations.

Audience Interpretation of Anger into Fear				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Anger, fear, surprise. Potentially confusion, disgust.	*(No comments).*	An attempt to assess the situation, confusion, disbelief.	An unexpected or shocking event, shocking news delivered quickly, an immediate threat is perceived.
Seq.2 Tim.A	Anger, fear, surprise. Potentially disbelief, disgust, sadness.	Potentially genuine *(one comment).*	Appraisal of a change in circumstances based on observation.	Tables turn on the character, from a position of power to a position of weakness.
Seq.2 Tim.B	Anger, fear, surprise. Potentially disbelief, denial.	*(No comments).*	Working out something, taking in information slowly.	Development and observation of a threat or of something horrific over time.
Seq.3 Tim.A	Anger, fear. Potentially surprise, disbelief, or difficult to read	*(No comments).*	Appraisal of change in circumstances, gathering and processing information.	Tables turn on character, a reaction to a horrific development.
Seq.3 Tim.B	Mixed emotions; anger, fear, disgust, surprise, confusion. Potentially pain, concentration.	*(Insufficient comments).*	Questioning, disbelief.	Context is dependent on feelings of disbelief and shock, potentially on something disgusting or frustrating.

emotions. For Seq.1, Seq.2 Tim.A and Seq.2 Tim.B, expressions of anger, surprise, and sadness were frequently discussed. This could suggest that the initial appearance of the sneer in the lower face choreographies helped with disgust recognition (a finding which also emerged in previous studies, discussed in Chapters 4 and 5). Where comments were made regarding authenticity, choreographies of fear into disgust were predominantly regarded as inauthentic or fake. Participants had difficulty in proposing more varied contexts, typically falling back on physical disgusted reactions to something which was foul looking or smelling, or watching a gory horror film. Upper face

Table 6.27: Summary of audience interpretation of fear into disgust animations.

Audience Interpretation of Fear into Disgust				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Fear, disgust, anger, surprise. Potentially sadness.	*(Insufficient comments).*	An immediate and natural disgust response, repulsive.	A disgust reaction to an observation, watching a horror / gory film.
Seq.2 Tim.A	Fear, disgust, sadness. Potentially anger, surprise, interest	Inauthentic.	Observation of an unexpected, horrible stimulus, still wanting to look.	A disgust reaction to an observation, watching a horror / gory film.
Seq.2 Tim.B	Fear, disgust, surprise, anger. Potentially disappointment, difficult to read.	Inauthentic.	*(Insufficient comments).*	Potentially suited to an “extreme” context, where contempt rather than disgust is experienced.
Seq.3 Tim.A	Fear, disgust. Potentially surprise, disbelief.	*(No comments).*	Taking in information, observation of something disgusting.	More widely applicable to situations where a “physical reaction” is experienced.
Seq.3 Tim.B	Fear, disgust. Potentially anger, surprise, difficult to read.	Inauthentic, fake.	Disgust and then acceptance, masking fear with disgust.	Suited to physical disgust situations.

leading with distinct timing (Seq.2 Tim.B) was more closely associated with contexts where contempt rather than disgust would be experienced, for instance a reaction to the inappropriate or distasteful behaviour of another individual.

6.5.2.6 Disgust into surprise

Finally, participants were able to accurately identify both disgust and surprise when viewing all five animations of the transition. Anger was discussed for simultaneous movement and lower face leading with overlapped timing, while happiness was also observed in the latter choreography. The variations of disgust into surprise were broadly seen as

Table 6.28: Summary of audience interpretation of disgust into surprise animations.

Audience Interpretation of Disgust into Surprise				
EEC	**Identification**	**Authenticity**	**Character**	**Context**
Seq.1	Disgust, surprise, anger	Inauthentic.	*(Insufficient comments).*	Suitable to an extreme change in circumstances or events, perhaps comedic or unrealistic.
Seq.2 Tim.A	Disgust, surprise. Potentially anger.	Potentially authentic *(few comments).*	*(Insufficient comments).*	Perhaps observation of an event shifting from disgusting to surprising (few comments).
Seq.2 Tim.B	Disgust, surprise. Potentially anger, happiness	Inauthentic faked.	Slower realisation, sinks in.	Something shocking or surprising is gradually revealed; e.g. viewing a birth
Seq.3 Tim.A	Disgust, surprise, anger, happiness. Potentially disbelief.	Inauthentic.	Two stages; threatening, shock, coming out of a daydream.	Could work in a scenario where the antecedent event for surprise is bizarre or very unusual.
Seq.3 Tim.B	Disgust, surprise. Potentially anger, fear, difficult to read	Inauthentic, faked, unnatural.	Forced, unexpected realisation.	Potentially useful in a situation where an individual that the character is cross with suddenly becomes threatening or horrible.

inauthentic, fake, or unnatural, with only a few comments supporting upper face leading with overlapped timing (Seq.2 Tim.A) as a potentially authentic choreography. As shown in Table 6.28, context was once again linked to the timing of movement, with simultaneous movement regarded as more appropriate for an extreme and sudden surprise, while Seq.2 Tim.B was matched with a slower unveiling of something surprising.

6.5.3 Discussion

6.5.3.1 Interpretation of emotion

Firstly, the question of whether emotional expression choreography would affect participant interpretation of animation was clearly addressed by the findings. In line with earlier empirical findings regarding the identification of emotion (see Chapter 5) and the existing literature (see 2.1.3), these studies showed that certain emotions are generally easier to identify (happiness, sadness, and surprise) while others can be more easily confused (anger, fear, and disgust). This proved to be a vital outcome, in that alignment between qualitative findings and the more typical quantitative research findings adds weight to the selection and validity of the focus group method, and demonstrates how this approach to researching expression interpretation may prove a useful strategy in future studies – particularly when it comes to contextualising statistical findings. Although participants were able to accurately identify the intended emotions in all cases, as was the case in the experimental study, the added depth of the focus group study revealed what other emotions or feelings participants may pick up on while viewing animation. Additionally, it emerged that participants discussed the authenticity of the animation frequently. The more detailed comments on why expressions may or may not appear authentic, detailed in Appendices XXVIII and XXIX, offered new insights into the exact nature of choreographed emotional expressions. When coupled with the experimental findings of Chapter 5, these insights would prove invaluable in developing a detailed description of the effects of EEC.

6.5.3.2 Interpretation of cognitive processes and context

The second and third research questions concerned whether the application of EEC would affect participant interpretation of thought process (or character) and possible contexts. As shown in the series of tables throughout this section, participants were capable of interpreting much more than the emotional expression and expression authenticity. For each of the twelve emotional expressions and transitions, potential thought processes and character attributes were identified and discussed (see Appendix XXIX for full comments). The quality of these results, in terms of the depth of participant comments and interpretations, allowed for a much more meaningful reading of the effect of EEC on character. For instance, changes in choreography led to participant comments which indicated that the character may be reflecting, feeling disagreeable, distrustful, processing information, disguising their true feelings, or even that they may have ulterior motives. In terms of context, participants offered a substantial number of scenarios which may be suited to particular EECs (detailed in Appendix XXIX). The summaries of character and context provided in the tables may be used in the development of more precise descriptions of how choreographed animations may be interpreted, specifically as regards what the character could be thinking and why they may be thinking it – a key consideration for character animators (as discussed in Chapter 2).

6.6 Chapter summary

The phenomenological study of animation production looked to investigate the practice of student animators in order to determine whether fellow animators would show a consensus of opinion (with the researcher and with each other) regarding the role of choreography in facial animation. The results indicated that there were aspects of EEC which the participants agreed upon; for instance the identification of preferred or problematic choreographies as applied to various emotional expressions and expression transitions. The findings of the phenomenological study of animation production underpinned the findings of the performative research described in Chapter 4. In some cases, participants came to similar conclusions regarding the clarity, authenticity, and context of choreographed facial animations when tasked with experimenting with animation through practice. Nevertheless, a degree of individuality in participant experience was also highlighted, pointing to the fact that animation practitioners will also draw subjective conclusions regarding the effect of emotional expression choreography. The second study of animation perception (conducted using focus groups) produced a substantial amount of qualitative data related to audience interpretation of choreographed expressions, in terms of; emotions, feelings, authenticity, thought process, and possible contexts. As with the results discussed in Chapters 4 and 5, the findings of these studies provided a new understanding of the potential effects of emotional expression choreography on the production and interpretation of facial animation.

At the start of this chapter, a quotation from Krueger and Casey (2009) was used in order to contextualise the adoption of qualitative methods for social science research. Specifically, the main problem encountered when trying to make studies of human behaviour fit the research protocols of the natural sciences was the limited scope of experimental methods and designs. In essence, the detail which can be revealed and examined using qualitative methods is often missed by experimental methods. This pitfall of a strictly experimental approach to perception research has previously been identified by Pizlo (2001). In the case of a study of emotional facial expression animation, the limitations of the experimental findings discussed in Chapter 5 were all too apparent. Despite the discovery of statistically significant differences in terms of observer perception of expressions, it was not possible to explore the deeper meaning of choreographed emotional expressions using a strictly experimental approach. In this chapter, the findings of two studies demonstrated that qualitative research into facial animation production and perception can be used not only to support but also to contextualise experimental findings. The findings discussed in this chapter proved vital to the overall study of the effects of emotional expression choreography. Ultimately, the range of performative, quantitative, and qualitative findings regarding the effects of EEC would allow for a multi-perspective assessment of EEC as applied to a range of expression animations, and underpin the future development of a detailed guide which could be of practical use to character animators.

Chapter 7
Emotional expression choreography:
discussion, implications, and future research

In this final chapter, the concept of EEC is evaluated based on the findings of performative experimentation, quantitative assessment of observer perception, and qualitative studies of animation production and interpretation. The introductory chapters provided a practical and theoretical context for the concept and study of EEC. The subsequent research described in Chapter 4 revealed that configuring facial dynamics within hand-key animation was a complex matter, but that systematic production and structured reflection could lead to informed artistic judgements. Those judgements were put to the test in Chapter 5 which demonstrated that, while measuring observer perception of animation was often difficult, it is possible to extrapolate perceived differences in terms of the authenticity of choreographed expressions. In Chapter 6, practitioner and audience interpretations of the effect of EEC were examined in an attempt to contextualise choreographed expressions. Here, it was shown that a consensus of interpretation could be reached, particularly in terms of perceived authenticity. However, individual interpretations were more prevalent for issues such as context and character, and ultimately the idiographic nature of the studies meant that the findings were not open to generalisation. Individually, the research discussed in these chapters offered new insights into the concept of choreographing emotional expressions, in particular with a view to enhancing the authenticity of animation. It was possible to establish artistic predictions of authenticity informed by practice, assess the perceptual validity of choreographies, and reveal intersubjective interpretations of a range of choreographed emotional expressions. By adopting the tri-paradigm methodology presented in Chapter 3, however, the culmination of the findings would allow for a holistic interpretation of the effect of EEC on animation production and reception. As such, this chapter is as much a review of the strengths and weaknesses of the unique methodological framework designed for the Emotional Avatars project as it is about project findings in relation to the initial project aim (see 3.1).

7.1 Discussion

At the outset, the rationale for a study of emotional expression animation was laid out within the context of interactive computer game characters. Games were the start point for the research, in particular the idea that the autonomous virtual performers of future story-driven games would be dependent on an extended understanding of what makes for believable, emotional animation. The history of game character behaviours and dynamic animation presented in the first chapter and discussed elsewhere (Sloan, 2011) set the scene for the project, while the interviews with leading industry practitioners and the review of associated literature in Chapter 2 demonstrated the potential power of an artistic approach to facial animation research. In particular, the idea of developing a recipe book – which later became the concept of emotional expression choreography – was underpinned by a gap in the existing research regarding the performance, presentation, and assessment of temporally manipulated facial expressions. The subsequent stated goal of the Emotional Avatars project was to make use of artistic animation practice in order to rigorously explore the concept of emotional expression choreography – the spatiotemporal configuration of facial animation. In reviewing the research context, it was clear that the vast majority of published facial expression research was conducted using established scientific research methodologies, predominantly in computer animation and psychology. While the practice of character animation had indeed been written about extensively and often linked to theories of facial expression movement and perception, to date there had been few published research articles that embraced creative animation practice as a viable method of research in itself. Certainly, no existing research directly linked creative facial animation practice to the development and scientific testing of theory.

With the potential role of artistic studio practice within a study of facial animation in mind, the following project aim was proposed:

> ‘To conduct practice-based studies of animation in order to explore the concept of emotional expression choreography, and develop an artistic understanding of dynamic expression animation that can be assessed and contextualised through studies of human perception and interpretation.’

From this declaration, a unique practice-led methodology was developed and presented in Chapter 3. This methodology was founded upon an underlying theoretical framework which concerned the intertwining of three epistemological perspectives, each addressing an area of the project aim; to explore expression dynamics through artistic practice (performative research), to assess the effects of choreographed expressions on observers (quantitative research), and to contextualise the meaning of choreographed expressions (qualitative research). Each of these three areas of research addressed a specific research question:

1. Can creative animation practice reveal a means of choreographing perceptually valid emotional facial expressions?
2. Will emotional expression choreography modulate observer perception of animated expressions?
3. Will animators and audiences show consensus in their interpretation of choreographed emotional expression animations?

In the following sections, the outcomes of each of the three primary areas of research shall be presented individually, before a holistic interpretation of the findings is discussed. Firstly, the defining characteristics of EEC shall be considered and reviewed.

7.1.1 The characteristics of emotional expression choreography

Throughout the life of the project, the core components of EEC were proposed, tested, evaluated, and refined. The overarching goal was to ensure that the characteristics of EEC were both applicable to practitioners (in order to develop the foundations of a recipe book), as well as practical to test using scientific methods. Initially, the spatiotemporal characteristics of EEC were put forth as being the movement of the three principal facial regions as discussed by Ekman and Friesen (1975), in addition to consideration for the sequence, timing, severity, and duration of movement (see Chapter 4). Practical experimentation with these characteristics ultimately led to a reduction in the number of facial regions from three to two (combining the brows and eyes into one region). This made for a more intuitive animation of expressions in keeping with the literature (Clark, 2002; Kalwick, 2006; Osipa, 2007; Williams, 2001), as well as a more effective assessment of observer perception (Chapter 5). Practice-based studies of the sequence, timing, severity, and duration of animated expressions (see Chapter 4 and Appendix X) led to a project focus on the sequence and timing of the two facial regions for a more in-depth investigation into the EEC concept.

In addition to the characteristics of the movement of expressions, the perceptual attributes of expressions were considered. From the literature (Chapter 2), development of methodology (Chapter 3) and practice-based studies (Chapter 4), these were identified as being the; identification of emotion, authenticity of animation, intensity of emotion, and animation context. From the research findings discussed in the following sections, it became clear that authenticity was the central attribute of interest. Defined as how natural and sincere an animation appeared, authenticity was the attribute which the practitioner-researcher found easiest to discern through practice (Chapter 4), the measurement of observer perception which was most clearly affected by EEC (Chapter 5), and the area where student practitioners showed the highest degree of consensus when reflecting on animation (Chapter 6). In comparison, it was evident that observers were easily able to identify an emotion in most cases, irrespective of EEC (Chapter 5). Emotional intensity could be matched to the severity of facial movement (Sloan, Cook and Robinson, 2009). Findings for context were revealed through practice-based and phenomenological studies (Chapters 4 and 6). These findings were ultimately more useful as supporting explanations for the perceived authenticity of EEC, as the potential context was highly dependent on the individual interpretations of animators and audiences. As such, the major contribution of the research related to the effects of EEC on the authenticity of expressions, from the perspectives of artistic practice, observer perception, and intersubjective interpretation. This outcome of the research was somewhat apt, considering that the perceptual problems posed by hyperrealism and performance capture (in relation to the uncanny valley effect, see Chapter 2) directly concerned the issue of authenticity. By determining how temporal authenticity could be enhanced using a multitude of research methods, the Emotional Avatars project subsequently made an appropriate contribution to the ongoing research in facial animation production.

7.1.2 Findings of the performative research

Through practice, the practitioner-researcher found that experimentation with the sequence, timing, duration, and severity of regional facial movement had an impact on his interpretation of the spatiotemporal configuration of expressions. These findings were framed by the practical understanding of the animation principles and a theoretical understanding of emotional psychology (as discussed in Chapters 2 and 3). Structured reflection on practice helped the practitioner-researcher to clarify his interpretations by considering four main issues regarding choreographed expressions; how artistically intuitive they were to apply, their potential authenticity, their potential clarity, and their possible contexts. In Chapter 4, the findings of structured practice and reflection were detailed for each of the six emotional expressions (4.4) and each of the six expression transitions (4.5), with the final focus being on the sequence and timing of the upper and lower facial regions. Here, it was shown that subjective yet informed predictions could be produced by the practitioner-researcher. For instance, leading with the lower face with overlapped timing (Seq.3 Tim.A) was found to be an intuitive, clear, and authentic choreography when applied to the expression of happiness. Additionally, it was proposed that it would be useful in a context which called for a ‘genuine, heart-felt happiness’. The same EEC as applied to anger was found to be counterintuitive, unclear, and inauthentic, suitable only to a context which insisted upon a mixed emotion of disgust and anger. Although two EECs emerged as being generally effective and ineffective (Seq.2 Tim.A and Seq.3 Tim.B respectively), variability in the intuitiveness, clarity, and authenticity of EECs was found to be dependent on the emotion being animated. This demonstrated that the previous literature on animation production offered only a simplistic (Clark, 2002; Kalwick, 2006) or reserved (Williams, 2001) view of facial movement (see discussion on animating facial performances, section 2.2.3), in that the the temporal order of movement for facial expressions must be connected to the emotion being animated, and to the overall context. The results indicated that, from the perspective of character animation, the movement within the face may require a higher degree of subtlety to enhance authenticity – particularly so as the control choreography (simultaneous movement, or Seq.1) did not emerge as a leading EEC for clear or authentic expressions across the board. The finding that authenticity could be enhanced by leading with the upper face in most cases and leading with the lower face in select cases was particularly important, as it called into question the validity of straight blends (simultaneous movement) in previous studies of dynamic expression animation (see the review in 2.3.2). As problems with an exclusively experimental approach to assessing dynamic facial animation had been raised (see 2.3.1), the successful execution of a practice-led study demonstrated that alternative modes of inquiry could be embraced to shed light on this complex area of research. The predictions of the practitioner-researcher – shown in the tables throughout Chapter 4 – were subsequently brought forward to inform the quantitative and qualitative studies.

7.1.3 Findings of the quantitative research

The results of the experimental methods used to measure and assess observer perception of choreographed emotional expressions were presented in Chapter 5. In the two main experiments – one looking at the practitioner-researcher's animations of the six emotional expressions, and one looking at the six animations of expression transitions – it was found that the majority of the predictions for authenticity outlined in Chapter 4 held true. When the predictions for which EECs would be perceived as authentic and inauthentic were considered, experimental findings corroborated the practitioner-researcher's predictions for sadness, anger, fear, surprise, surprise into happiness, happiness into sadness, fear into disgust, and disgust into surprise. This was perhaps the most compelling finding of the quantitative research, as it demonstrated the potential for reflective artistic practice to accurately predict the perceived authenticity of animation. While this concept was well understood by the animation community (it lies at the heart of the principles of animation), it had not previously been demonstrated through a combination of character animation and empirical research. As regards the perceived clarity of expressions, it was found that the effects of EEC did not have a significant impact on observer perception in the majority of cases (the identification of disgust expressions being the only instance where EEC had an effect). This outcome could be attributed to sample size (in that a larger sample may provide enough power to find significant differences). However, it is expected that the proven universality of the expressions under test (see discussion in Chapter 2) is the more likely reason that clarity was not substantially affected by choreography. In other words, the observers were capable of decoding the emotional signals of every expression with a high rate of success, irrespective of EEC. On the whole, then, the quantitative findings demonstrated that the proposed EEC framework modulated observer perception of animated expressions, but that the effect was exclusively in terms of perceived authenticity. In order to tease out further information regarding the potential interpretation of choreographed facial animation, two qualitative studies were conducted.

7.1.4 Findings of the qualitative research

The findings of the phenomenological study of animation production demonstrated that intersubjective majority could be reached after reflection on the creation of animation following the EEC concept. Research participants showed agreement regarding how clear and intuitive choreographies were as applied to the range of emotions, and also discussed potential effects on context and character. Discussion of context in particular helped to contextualise participant interpretation of the animations they were creating (see Appendix XXII). These findings complimented the results of the performative study (Chapter 4), providing an extended interpretation of EEC context beyond the subjective interpretations of the single practitioner-researcher. However, it was the findings for authenticity that once again proved to be of most interest. While majority consensus on clarity and intuition was observed in some cases, majority consensus on authenticity was found for every animation except the expression of disgust. Not only did the student animators identify which EECs they felt were most or least authentic, but these findings also corroborated many of the predictions of authenticity laid out in Chapter 4 (see 6.3.4). This outcome proved to be vital to the success of the mixed methods approach, and added further weight to the notion that studio practice could be used to conduct detailed research into facial expression animation. The findings of the first qualitative study added to the existing knowledge base on facial animation on two fronts; by showing that EEC can affect practitioner interpretation of authenticity, and by demonstrating that qualitative approaches (as opposed to the largely experimental approaches discussed in Chapter 2) can be used to generate results. The second qualitative study sought to provide extended insight into the effect of EEC on audiences. The findings of this study supported the experimental research, in that focus group members were able to identify expressions with a high degree of success. Beyond this, participant comments could be clustered in order to determine what other emotions, feelings, and thoughts may be associated with particular EECs. These comments provided more data which would later be vital in putting together an evidence-based recipe book for emotional expression choreography. In terms of showing consensus on context, it was found that participants would attribute ideas of emotional sincerity, narrative, and character to the expressions they were viewing in most cases. Comments on authenticity indicated whether participants found EECs to be genuine or fake, natural or unnatural. The descriptions provided by the observing audiences (reduced and presented in 6.5) provided an additional resource which could inform animation practice and substantiate experimental findings.

7.1.5 A holistic interpretation of the findings

In reviewing the findings of all studies, it was clear that each study in isolation had successfully contributed new knowledge to the research domain. Individually, each study yielded findings which helped to inform and develop the concept of EEC and to corroborate existing predictions (e.g. Bänziger and Scherer, 2007; Keltner, 1995; Krumhuber, Manstead and Kappas, 2007; Messinger et al., 2001). The performative research was pivotal when it came to experimenting with spatiotemporal attributes and refining an EEC framework that would be useful in both practice and in experimental research. The reflections of the practitioner-researcher identified many of the core issues relating to the effects of EEC, resulting in predictions of authenticity and clarity. The outcomes of performative research were subsequently assessed in the quantitative phase of the research, which provided statistically significant results confirming predicted effects of EEC on authenticity. Qualitative findings further substantiated performative predictions on authenticity, and offered interpretations of potential contexts for EEC as applied to the range of emotions and transitions under investigation. The authenticity of EECs emerged as the main focal point when analysing the effects of EEC from the three research angles. As shown in Figures 7.1 and 7.2, consistency between the performative, quantitative, and qualitative findings for the authenticity of EECs was evident in a range of cases. Holistically, it was clear that an animation of sadness was most authentic when Seq.2 Tim.A was applied and least authentic when Seq.3 Tim.B was used. Similarly, an animation of surprise into happiness was shown to be

Figure 7.1: An overview of the findings from all three research chapters regarding the authenticity of choreographies as applied to emotional expressions. For the focus group findings, only examples where sufficient comments were provided that strongly indicated an EEC was authentic or inauthentic are shown.

Figure 7.2: An overview of the findings from all three research chapters regarding the authenticity of choreographies as applied to emotional expression transitions. For the focus group findings, only examples where sufficient comments were provided that strongly indicated an EEC was authentic or inauthentic are shown. For the focus group finding for Seq.2 Tim.B of Happiness into Sadness, participants indicated that the happy expression was inauthentic and that the sad expression was authentic.

most authentic with either Seq.3 Tim.A or Tim.B, and least authentic with Seq.2 Tim.B. In other cases, consistency between findings for two studies was shown. For example, the findings of the performative and student animator studies demonstrated that Seq.3 Tim.A was the most authentic EEC for happiness. The quantitative study yielded no significant findings for the authenticity of happiness, suggesting that the other selected methods of research were more effective in determining authenticity here. There were also instances where there was consistency between performative and quantitative findings, but no support from the qualitative findings; for example, Seq.2 Tim.A was found to be authentic for fear into disgust.

Looking at the data generated as a result of the performative and qualitative studies, explanations for these findings can be revealed. For instance, lower face leading with distinct timing (Seq.3 Tim.B) was conclusively found to be inauthentic for an expression of anger. While assessment of observer perception could only demonstrate that this was true, the comments provided by the practitioner-researcher, student animators, and focus group audiences could be examined in order to ascertain why this might have been the case. Here, the student animators indicated that this particular EEC when applied to anger appeared “very faked and forced”, that it “didn’t seem incredibly believable/fluid in motion”, and that “it doesn’t have the quickness which makes it lose even more of the supposed anger it is meant to be showing” (see Appendix XXVI). As such, statistically significant findings for authenticity could be compared against the comments on clarity, authenticity, and context contained within the results of the other studies (Appendices XII, XIV, XXIV, XXVII, XXIX). Therefore, the development and application of a tri-paradigm methodology – led by studio practice – was not only effective in addressing the project aim, but also emerged as a novel approach to tackling a fundamentally complex issue. By producing and analysing artistic, empirical, and interpretive data related to the animation and perception of emotional facial expressions, a more complete understanding of the potential effects of EEC could be reached. To focus the findings of these studies into one conclusive project outcome, a 'recipe book' for emotional expression choreography was created (see Appendix XXX), as initially proposed in Chapter 1. This evidence-based document was developed to demonstrate how the project findings may be used as a manual, by practitioners and researchers, on how to produce artistically and perceptually valid facial expression animation. The production of this document at the conclusion of the project showed that the initial aim had been successfully addressed by the research, and that the findings could be of practical application in future character animation projects.

7.2 Implications and limitations of the research

Both theoretical and practical implications can be derived from the findings discussed in this thesis. Firstly, the development of a practice-led approach to the production and assessment of facial animation represents a marked shift in epistemological approach to the subject matter. As discussed in Chapter 2, the most closely related research – in terms of studies of facial movement – typically concerns an objective approach to expression animation. From the perspective of psychology-orientated studies, research into facial movements are primarily rooted in the initial observational studies of static expressions (Ekman and Friesen, 1975), the development of FACS (Ekman and Friesen, 1978), the assessment of observer perception of movement (Bassili, 1979), theories and models of emotion (e.g. Plutchik, 1980), and theories of behaviour and emotional appraisal (e.g. Scherer, 1999). The focus on the natural occurrence of facial movement has fed into most facial animation research (e.g. Arya et al., 2006; Cunningham and Wallraven, 2009a; Nusseck et al., 2008; Malatesta et al., 2006; Wehrle et al., 2000), while the use of performance capture technology (rather than hand-key animators) has been used to drive facial animation. Technical research into facial animation predominantly concerns techniques and procedures for synthesising expressions (Deng and Noh, 2007; Parke and Waters, 2008). As regards the production of embodied conversational agents, research in this field has stemmed from observational studies of expressions and psychological models of emotion (e.g. Pelachaud, 2009a), although the creative animator's production of animation has been acknowledged (e.g. Tomlinsion, 2005; Pelachaud, 2010). In this context, the practice-led methodology discussed in this thesis represents a theoretical departure from the norm, affording a pivotal research role to traditional animation production within the broader field of facial expression perception and synthesis. In particular, the application of animation as a research method can be used to address the problem of expression posing. It was discussed that, in psychology research, the posing (or acting) of expressions is regarded as a valid means of investigating face appearance and perception (Rosenberg, 2005), but that a perceived distinction exists between posed and spontaneous (naturalistic) expressions (Gosselin et al., 2005). The design of the practice-led methodology demanded that the practitioner-researcher develop an understanding of a broad range of emotional psychology literature related to; the experience of emotion in nature (Cosmides and Tooby, 2000; Ekman, 1992; Lang, Bradley and Cuthbert, 1999; Levenson, 1992; Plutchik, 1980; Schupp et al., 2004), theories of appraisal (Scherer, 1999), social factors (Ansfield, 2007; Esteves and Arne, 1993; Patterson, 1983; Zeman and Garver, 1996) and cultural factors (Ekman, 1989; Friesen, 1972; Ramsey, 1984). In addition, a thorough understanding of facial appearance (Ekman and Friesen, 1975) and anatomy (Ekman and Friesen, 1978; Faigin, 1990) was required. Using this literature as an intellectual basis, the practitioner-researcher was able to draw upon his practical expertise in animation, his understanding of animation principles (Thomas and Johnston, 1981), and knowledge of animation techniques like reversal (Clark, 2002) in order to investigate the production of posed (animated) expressions, but with a firm foothold in the psychology of emotion and naturalistic expression. As such, the methodology and subsequent findings not only connect to the existing work in emotional psychology (in that the same models and theories of emotion are used as a foundation), but also demonstrate how a more rigorous approach to 'posing' expressions can be taken. In the Emotional Avatars research, many months of studio practice were invested to generate the animated expressions, and a trail of data was generated as a result. This approach is clearly distinct from existing methods of posing expressions using actors, where the production of the expressions is typically treated as a means to an end – a quick way of generating synthetic expressions. As further studies based on the animation-led methodology are planned, the findings of the Emotional Avatars research should have implications for the design of future research into performance-based facial animation and perception.

Specifically regards the existing research into facial dynamics, the research presented in this thesis can be regarded as a step towards a more thorough understanding of the temporal configuration of emotional expressions. Past work has shown that expressions do unfold sequentially (Bänziger and Scherer, 2007; Messinger et al., 2001), while research into sequential animation of expressions based on appraisal has been conduced (Malatesta, Raouzaiou and Kollias, 2006; Paleari and Lisetti, 2006; Wehrle, 2000). The relative role of facial regions to expressions has been demonstrated (Adolphs, 2002; Calder and Young, 2005; Nusseck et al., 2008). However, very little evidence has been uncovered which supports the notion that the temporal manipulation of facial regions can modulate the authenticity or potential context of expressions or transitions. As such, the Emotional Avatars research could have implications for the future development of ECAs (Newiadomski, Hyniewska and Pelachaud, 2009; Pelachaud, 2009a), as first identified in Chapter 2 (see p 97).

In practice, the implications of the research on the development of interactive characters and on animation production are clear. The combination of performative, experimental, and phenomenological findings demonstrated that the sequence and timing of facial movement can have an effect on facial animation production and perception. An understanding of the artistic reasoning behind choreographed facial movement – evidenced by the performative findings of Chapter 4 and the phenomenological study of Chapter 6 – could be used to inform the procedural animation of emotional virtual characters. The current understanding of natural facial movement is itself limited by the variability inherent in nature and, besides theories such as Scherer's appraisal, no substantial evidence regarding the natural sequence and timing of facial movement has been presented thus far. With a focus on the optimal configuration of movement from the perspective of animation practice, the findings of the current research can pave the way for artistically-informed dynamic facial animation. Furthermore, the project findings have proven to be of interest to practising animators; a summary of the main research findings were reviewed by and presented to members of the Society of Animation Studies towards the end of the project (Sloan, 2010). As discussed earlier, the existing literature on facial animation for animation practitioners (Kalwick, 2006; Osipa, 2007; Williams, 2001) was found to be informative but lacking in either detail or consistency when facial movement was considered. As such, the findings of the current research would prove to be an effective resource when planning and creating facial animation (see Appendix XXX for an example of this).

In terms of limitations, it must be re-iterated that the findings discussed in Chapter 4 were the outcome of subjective, reflective practice conducted by the practitioner-researcher alone. It could be proposed that another animation practitioner, conducting a similar study under the same conditions, could quite feasibly establish a different array of findings. Indeed, this was observed with the phenomenological study of animation production (Chapter 6). However, the subjectivity of arts-research – as discussed in Chapter 3 – is a distinguishing feature which sets performative research aside from the objectivity of scientific paradigms. Furthermore, the complimentary methods discussed in Chapters 5 and 6 allowed for objective and intersubjective views on the production and perception of choreographed emotional expressions.

In the publication and presentation of Emotional Avatars research since 2008 (Sloan, 2010; Sloan et al., 2008, 2010a, 2010b, 2010c; Sloan, Cook and Robinson, 2009; Sloan, Robinson and Cook, 2009a, 2009b, 2009c) the methodology itself emerged as one of the major points of discussion. That animation practice has been adopted as a viable research method – that it has been used to generate new understandings of facial movement and develop predictions, and that those predictions have been shown to align with the findings of experimental and qualitative research – is arguably the major outcome of the project.

7.3 Future research

The design and evaluation of facial animation for interactive characters is a growing area of interest for researchers working within and between fields as diverse as computer graphics, affective computing, psychology, and media studies. As both computing power and consumer demand for perceptually valid game characters increases, it is expected that this field is likely to expand. Groups such as HUMAINE (2010) demonstrate the high levels of activity of current cross disciplinary researchers, while industrial R&D departments in the film and game industries continue to push the boundaries of computer generated facial animation performance. The Emotional Avatars project presented the idea of studio practice as a further research discipline which can contribute to the expanding knowledge base. By conducting studio-based research into the concept of emotional expression choreography, it was clear that this approach could be adopted in order to explore a range of associated research questions in the future.

In developing the character rig for the facial animation study, questions regarding the role of character gender, character appearance, and character style were considered. In the current research, the impetus was with facial movement, and as such steps were taken to produce an androgynous, realistically proportioned character. However, the effects of character gender and appearance on observer perception have been studied from psychological and biological perspectives, and a future study of studio-based character design for animation may serve to compliment this work. In addition, the role of body language and movement represents a key issue which can be tackled using the practice-led methodology discussed in this thesis. Future studies will therefore seek to address the artistic production of emotional body language and other nonverbal cues, with assessment of the results conducted through tests of observer perception. The issue of the uncanny valley (or uncanny cliff) effect, in terms of the perceptual validity of nuanced expression movement, is another avenue for further research. There is scope for a study comparing the output of performance capture technology, hand-key animation, and also the combination of both methods in order to establish how this most believable facial animation may be produced.

As regards the animation of facial expressions, the research presented in this thesis only scraped the surface of the emotional expression choreography concept. Now that the practice-led methodology has been tested and shown to produce results, future research will seek to study the animation of more complex emotions and affective states, such as those discussed by Plutchik (1994). Additionally, a broader range of transitions shall be investigated using studio-based methods of investigation. The research described in this thesis ultimately focussed on the sequence and timing of facial regions. Other avenues which were partially explored prior to this focus – namely the severity and duration of movements – will be explored in more depth. This future work shall aid in the development of an expanded taxonomical description of emotional expression choreography (Appendix XXX), which shall benefit animation practitioners as well as inform the production of procedural animation for interactive characters.

At the start of the research, the primary question was whether a practice-based study of facial animation could help to inform future development of believable computer avatars. In particular, it was proposed the procedural animation techniques would prove to be the only feasible method of bringing these interactive virtual characters to life; to enable them to “act well enough to embody an interactive narrative” (Perlin, 2004, p 17). At the conclusion of the project, it is clear that there is a role for practice-based research in the development of these virtual actors. The formation of a viable mixed-methods approach enabled a holistic interpretation of performative, quantitative, and qualitative data in order to shed light on the potential effect and meaning of variation in performance dynamics. Now, the research focus must shift to how the understanding of dynamic animated performance might be extended, and how the gap between the theory and technological application of emotional expression choreography might be bridged.

Appendices

I Interviews with industry professionals

Two interviews with games development professionals; Jolyon Webb (Blitz) and Robert Strand (Codemasters), July 2010. Complete unedited audio files and key excerpts from these interviews are included in the Appendix I folder on the accompanying DVD.

II Ekman's basic emotion characteristics

A description of Ekman's (1992) basic emotion characteristics is included in the Appendix II folder on the accompanying DVD. The definitions of these characteristics were used in the performative analysis (see 3.6.3.3).

III The experience and expression of the universal emotions

A comprehensive overview of the key literature related to the psychobiological experience and physical expression of the six universal expressions is contained within the Appendix III folder on the accompanying DVD. This background in emotional psychology and facial expression appearance underpinned the production and analysis of animation, covered in Chapter 4.

IV Template journal for animation production using the inquiry cycle method

A Word template was used to keep an ongoing journal of the practitioner-researcher's thoughts on EEC as part of the inquiry cycle method (see 3.6.1). The template is included on the accompanying DVD in the Appendix IV folder.

V Multimedia matrix used in animation analysis

The practitioner-researcher developed an Adobe Flash file in order to display sketches, animation, and journal data simultaneously. The matrix was essential in order to reduce and convey performative data, as discussed in 3.6.3.1. The final matrix is included on the accompanying DVD in the Appendix V folder.

VI Template structured reflection document used in animation analysis

A Word template was used to guide structured reflection on animation production, part of the performative methodology (3.6.3.2). The template is included on the accompanying DVD in the Appendix VI folder.

VII Generating naturalistic expression videos

In order to generate original, naturalistic expressions of emotion, a study was conceived in which participants would be exposed to emotionally evocative video clips while being filmed. Selected videos of the resulting expressions were then shown to observers, who were asked to identify and rate the emotions they perceived. A short overview of the procedure followed to elicit naturalistic emotional expressions among ten female participants is included on the accompanying DVD. Additionally, the captured videos are contained within the Appendix VII folder.

VIII Recorded footage of acted emotional expressions

The Appendix VIII folder on the accompanying DVD contains all of the videos of posed expressions which were used in the observational study (4.1.2.2), as well as the files which were used to instruct actors.

IX Development and testing of the emotional avatars facial animation rig

This appendix details the development and testing of the Emotional Avatars facial animation rig, which was used to produce all of the animation discussed in the thesis. The appendix is split into two files. The first file details the development of the facial animation rig, covering all technical aspects of how the 3D character setup was produced. The second file demonstrates how the facial animation rig was tested, framed by Ekman and Friesen's

(1975) description of the universal expressions. In addition, the final Emotional Avatars facial rig master file is included on the DVD. This can be opened with Autodesk Maya 2008 or later.

X Preliminary animation studies

Early performative studies included an exploration of expression severity, duration, and sequence. These studies greatly informed the development of the final EEC framework (4.3.1). Details of these studies can be found in the Appendix X folder on the accompanying DVD.

XI Final animations produced as a result of the preliminary studies

A series of animations were produced as a result of the preliminary animation studies described in Appendix X. These animated outcomes can be found in the Appendix XI folder on the accompanying DVD. This includes:

Eighteen animations produced of six emotional expressions (happiness, sadness, anger, fear, disgust, and surprise) at three levels of emotional intensity (low, medium, high).

Thirty-six animations produced of six emotional expressions (happiness, sadness, anger, fear, disgust, and surprise) at two levels of emotional intensity (low, high) and at three overall durations (75%, 100%, 125%).

Seventy-eight animations produced of three emotional expressions (sadness, fear, and disgust) using thirteen sequences of facial region movement (manipulating the brows, eyes, and lower face), and animating both the onset and offset of the expression.

XII Journal entries for animation study 1

An animation journal kept throughout the inquiry cycle stage of the methodology for animation study 1 (see 4.4). This document is included in the accompanying DVD in the Appendix XII folder.

XIII Final animations for animation study 1

Thirty animations created using the five levels of the final framework of emotional expression choreography. These animations depict; happiness, sadness, anger, fear, disgust, and surprise. All animations can be accessed via the Appendix XIII directory on the accompanying DVD. Videos can also be viewed in Appendix V.

XIV Journal entries for animation study 2

An animation journal kept throughout the inquiry cycle stage of the methodology for animation study 2. This document is included in the accompanying DVD in the Appendix XIV folder.

XV Final animations for animation study 2

Thirty animations created using the five levels of the final framework of emotional expression choreography. These animations depict; surprise into happiness, happiness into sadness, sadness into anger, anger into fear, fear into disgust, and disgust into surprise. All animations can be accessed via the Appendix XV directory on the accompanying DVD. Videos can also be viewed in Appendix V.

XVI Exposition materials

Three main exposition of work were staged by the practitioner-researcher throughout the life of the project. This included exposition staged at the University of Abertay Dundee in 2008 and 2009, and at the Sensation Science Centre in 2010. Materials generated for and collected at these expositions are included on the accompanying DVD in the Appendix XVI folder.

XVII Experiment: observer perception of naturalistic expressions

Details of an experiment design to measure observer perception of naturalistic expressions were published by the researcher at the SAND 2008 conference in Swansea, November 2008. This paper is included in the Appendix XVII folder on the accompanying DVD.

XVIII Experiment: observer perception of animated expressions

Details of two experiments designed to assess observer perception of animated expressions were published by the researcher at the Viz 2009 conference in Barcelona, July 2009. This paper is included in the Appendix XVIII folder on the accompanying DVD.

XIX Experiment: observer confusion between anger and disgust expressions

A study of observer perception of static disgust faces, produced using the Emotional Avatars character rig, was conducted by the researcher in order to establish at what point observers confused an expression of disgust with an expression of anger. Details of this experiment, including analysis and findings, are included on the accompanying DVD in the Appendix XIX folder.

XX Phenomenological description of the practitioner-researcher's experiences with EEC

As part of the selected phenomenological procedure (see 6.1), producing a complete description of the researcher's own experience of the investigated phenomenon (animating using EEC) was key to establishing validity. This description is included on the accompanying DVD in the Appendix XX folder.

XXI Documentation for the phenomenological study of animation production

All documents which were used by research participants in the study of animation production are included on the accompanying DVD in the Appendix XXI folder.

XXII Completed documentation for all participants of the phenomenological study of animation production

Participants of the phenomenological study of animation production created animations and completed documentation as part of their work. The completed documents were subsequently analysed using phenomenological methods. All participant documents are included on the DVD in the Appendix XXII folder.

XXIII Interview schedule for the phenomenological study of animation production

The following interview schedule was used as an aid when conducting one-on-one interviews with research participants.

1. Can you tell me about your experience as an artist?
Possible prompts: What was your education? What employment have you had as an artist? When you create artwork, how do you tend to make decisions?

2. Can you tell me specifically about your experience as an animator?
Possible prompts: What about tutorials or related reading? How aware are you of the principles of animation?

3. On to the animation project. Can you tell me about your experience prior to animation production, the animation preparation phase?
Possible prompts: How did you make judgements? How sure were you that these judgements were sound? Were any emotional expressions particularly easy or difficult to make judgements about?

4. Can you tell me how you felt about the process of animating facial expressions?
Possible prompts: How did you work with choreography? Can you tell me about revisions you made? What methods or tools did you use to help you? How did the process of animating affect your judgements on choreography?

5. Can you tell me how you felt about particular choreographies in relation to the range of emotional expressions you were animating?
Possible prompts: How did choreography make expressions seem more or less authentic? How did choreography affect the clarity of an expression? Could choreography make or break an animated expression?

6. Can you tell to what extent you felt choreography choice could be linked to context?
Possible prompts: For instance; the context of a story or overall narrative, the context of the character's personality or experience, or the context of the character's situation

or thought process. Could choreography be linked to the character's intentions, e.g. whether the character was faking, exaggerating, or masking emotion?

7. Can you tell me how you felt about each of the five choreographies in general?
Possible prompts: Seq1 / Seq2 TimA / Seq2 Tim B / Seq3 TimA / Seq3 TimB. Can you think of examples where this choreography worked well/did not work? Can you summarize how you felt about this choreography across all expressions? To what extent do you think the emotional expression(s) determines the suitability of a choreography?

8. Can you tell me to what extent you felt the process of animation planning and production helped you to come to conclusions regarding each choreography?
Possible prompts: Did you find choreographies to be more or less intuitive, and how did this vary by expression? Did you find choreographies to be more or less difficult to animate, and how did this vary by expression? Did the process of animating the expressions help you to understand the effect of choreography? Did it clarify or change your judgements?

XXIV Interview transcripts for all participants of the phenomenological study of animation production

Complete interview transcripts – which include descriptive, linguistic, and conceptual comments made by the researcher – are included on the DVD in the Appendix XXIV folder. Transcripts and evaluation documents were sent to all research participants as part of the data validation process. Participants were asked to read the commented transcripts and evaluation documents and confirm whether or not they represented an accurate account of their experience. The following letter was sent to participants.

Participant Validation of
Interview Transcripts and Evaluation Documents

I, the undersigned, confirm that I have read the transcript of an interview I participated in as part of a facial animation projected co-ordinated by lead researcher Robin Sloan. I have also read through the observations and comments of the interviewer. To the best of my recollection, I confirm that this is an accurate transcript of the interview I gave, and I agree that the observations and comments of the interviewer are fair.

In addition, I have also been provided with the evaluation documentation I completed while involved in the study. I can confirm that the comments in these documents accurately represent my thoughts and opinions on the production of choreographed emotional expression animation. Research participant name: ________________________________ Research participant signature: ______________________________

XXV Major themes and meaning units developed through interpretive phenomenological analysis

The following major themes and meaning units emerged through analysis of structured reflections and participant data. These themes were subsequently imported into NVivo in order to associate participant statements with themes and meaning units and synthesize results. Descriptions of these themes are included on the accompanying DVD in the Appendix XXVI folder.

Major Themes	Meaning Units
A Authenticity	1. Authentic expression animations 1.1. An expression that is natural 1.2. An expression that is sincere 2. Inauthentic expression animations 2.1. An expression that is unnatural 2.2. An expression that is insincere
B Emotional Purity	1. An expression that suggests a pure emotion 1.1. The intended emotion is conveyed 1.2. An unintended emotion is conveyed 2. An expression that suggested mixed emotions 2.1. The intended emotion is present 2.2. The intended emotion is not present
C Character Context	1. Reference to the type of character 2. Character mannerisms or personality 3. The character's thought process 4. Complex feelings experienced by the character 5. Masking of emotion 6. Displaying emotion 7. The intensity of the emotion experienced
D Situational Context	1. An emotional reaction

	2. A development of emotion over time 3. A specific narrative or situational context 4. Applicable to any context 5. Applicable to certain contexts 6. Not applicable to any context
E Facial Movement	1. Typicality of movement 1.1. Typical or general 1.2. Atypical or problematic 2. Control of facial movement 2.1. Voluntary movement 2.2. Involuntary movement 3. Speed of movement 3.1. Slow movement 3.2. Fast movement 4. Strength of movement 4.1. Weak movement 4.2. Strong movement
F Observation	1. Clarity of emotion 1.1. Clear expression 1.2. Ambiguous expression 2. Perception and interpretation
G Artistic Reflection	1. Artistic practice 1.1. Knowing in practice 1.2. Knowing in preparation 1.3. Practice changes pre-judgements 1.4. Practice reinforces pre-judgements 1.5. Practice does not affect judgements 2. Intuition 2.1. An intuitive animation 2.2. A counter-intuitive animation 3. Practicality 3.1. A practical animation to create 3.2. An impractical animation to create 4. Reflection on project 4.1. Animating without a given context 4.2. Non-emotional facial movements

XXVI Example participant comments from animation evaluation documents

Selected comments which were used to demonstrate participant interpretation of EEC are included in the Appendix XXVI folder on the accompanying DVD.

XXVII Documentation for the qualitative study of audience perception

Briefings, informed consent documents, and questionnaires used in the qualitative study of audience perception are included in the Appendix XXVII folder on the accompanying DVD.

XXVIII Transcripts of focus group sessions

Complete coded transcripts of focus group sessions (see 6.5) are included on the accompanying DVD in the Appendix XXVIII folder.

XXIX Analysis of coded transcripts

The following strategy was employed in order to analyse the focus group transcripts:

1	Each statement was read and considered in the context of the major themes (listed in transcripts of focus group sessions). If the statement fitted with one or more of the major themes, it was colour coded appropriately. If the statement did not fit with one of the major themes, it was left in black text.
2	On the second read through of the transcripts, each coded statement was reconsidered. The potential importance of the statement – in direct relation to the three research questions (see Chapter 6) – was then assessed.
3	Statements were then grouped under each theme, for each emotional expression/transition and for each EEC.
4	For each emotional expression/transition, statements under the grouped themes were considered
5	A short account of the audience interpretation of each choreographed expression was then written based on the associated comments.

The output of the analytical strategy is included on the accompanying DVD in the Appendix XXIX folder.

XXX Foundations for a recipe book of emotional expression choreography

As a final outcome after a holistic interpretation of performative, quantitative, and qualitative findings, a proposed emotional expression choreography recipe book was produced. This recipe book is included on the accompanying DVD in the Appendix XXX folder.

Glossary

Anticipation: One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that any major movement should be anticipated by a pre-requisite movement in order to prepare the audience.

Arcs: One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that natural looking animation ought to contain arc like movement.

AU: Action Unit. A unit of facial movement described by the Facial Action Coding System.

AU 12: One of the most commonly referenced Action Units. The activation of the Zygomatic Major, resulting in the appearance of a smile.

Authenticity: One of the measures used in the design and assessment of choreographed emotional expression animation. The overall believability of an animation, including how natural and sincere an expression is.

Automatic Appraisal: One of Ekman's basic emotion characteristics, used to frame performative analysis of facial animation. The idea that emotions are appraised either automatically or over an extended period, linked to Scherer's work on cognitive appraisal theories.

Brief Duration: One of Ekman's basic emotion characteristics, used to frame performative analysis of facial animation. The idea that emotions by definition and distinction from other affective states have short durations.

Distinctive Universals in Antecedent Events: One of Ekman's basic emotion characteristics, used to frame performative analysis of facial animation. The idea that emotional triggers are universal and based on evolution.

Distinctive Universal Signals: One of Ekman's basic emotion characteristics, used to frame performative analysis of facial animation. The idea that aspects of facial expression linked to emotion are universally displayed and recognised.

ECA: Embodied Conversational Agent. A virtual intelligence, usually represented by a graphical character, which has been designed to display lifelike behaviours.

EEC:	Emotional Expression Choreography.
Exaggeration:	One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that the animator should push movement to the limits in order to enhance audience perception and readability.
FACS:	Facial Action Coding System. A system of analysing and describing facial movement developed by Paul Ekman and Wallace Friesen.
Follow Through:	One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that animated elements of a character should continue to move after the main body has come to a halt
LMA:	Laban Movement Analysis.
NPC:	Non-playable character. A character in a computer game that is controlled by the game.
Overlapping Action:	One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that animated elements of a character may move at different rates.
Performative Research:	A third paradigm of formal research distinct from quantitative and qualitative traditions, proposed by Haseman. Essentially in line with what is often termed practice-based, practice-led, or visual arts research, where research is conducted in the studio by a practitioner-researcher and results are subjectively generated rather than revealed through analysis of numerical or textual data.
Quick Onset:	One of Ekman's basic emotion characteristics, used to frame performative analysis of facial animation. The idea that emotions by definition have short onsets.
Secondary Action:	One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that secondary actions should be shown in animation in order to support primary actions.
Seq.1	Sequence 1. An aspect of Emotional Expression Choreography, which dictates that both the upper and lower regions of the face should move simultaneously.
Seq.2	Sequence 2. An aspect of Emotional Expression Choreography, which dictates that the upper face region should move before the lower face region.
Seq.3	Sequence 3. An aspect of Emotional Expression Choreography, which dictates that the lower face region should move before the upper face region.
Slow In and Slow Out:	One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial

animation. The idea that animated elements should accelerate and decelerate between key poses.

Staging: One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The guideline that an idea should be presented so that it is unmistakably clear.

Squash and Stretch: One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The idea that animated objects should contain an element of flexibility in order to demonstrate weight and character.

Tim.A Timing A. An aspect of Emotional Expression Choreography, which dictates that there should be an overlapped timing between upper and lower face regions. Can be applied to either Seq.2 or Seq.3.

Tim.B Timing B. An aspect of Emotional Expression Choreography, which dictates that there should be an distinct timing between upper and lower face regions. Can be applied to either Seq.2 or Seq.3.

Timing: One of the principles of animation described by Thomas and Johnston, and used to frame performative analysis of facial animation. The consideration of the number of drawings or frames in between key poses.

Unbidden Occurrence: One of Ekman’s basic emotion characteristics, used to frame performative analysis of facial animation. The idea that emotions are typically unbidden, resulting from an external stimulus event.

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